TECHNOLOGICAL CHANGE AND FISHERIES DEVELOPMENT
THE CASE OF THE MEXICAN SHRIMP FISHERY AND SHRIMP AQUACULTURE

by

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ABSTRACT

We developed a qualitative and quantitative study to asses the economic impact of the implementation of shrimp aquaculture on the Mexican economy. The qualitative analysis was based on a functional institutional analysis and on property rights as a determinant of economic development. The quantitative analysis was based on the simulation of technological change, using a 1980, 93-sector input-output matrix of the Mexican economy. Using primary data on semi-intensive pond shrimp farming technology, as well as the industrial shrimp fishery, we developed capital-account and current-account vectors. The vectors, which were developed in 1980 prices, were substituted into the matrix to simulate technological change. The economic impact of technological change was measured by changes in the linkage profile of the economy. The linkage measures used, the coefficient of variation and the power of dispersion, estimated the strength and dispersion of the linkages over the economy.

Our analysis shows that the current account expenditure of the shrimp fishery has stronger economic linkages than aquaculture production. However, the linkages of shrimp aquaculture are dispersed more evenly among the sectors of the economy. Furthermore, the institutional framework, including the redefinition of property rights, is critical in determining the contribution to economic growth of wages, return to capital and government transfers.

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The funding of CONACYT would have been shallow without the dedication of some of the professors at MIT. In this light, the attention and commitment of Professor Karen Polenske to me and to my work was very special. Her technical expertise in input-output analysis as well as the insight that she brought into the issue of property rights were invaluable. In addition, the incredible detail in the corrections of the numerous drafts improved this work by an unmeasurable magnitude. Professor Paul Smoke, also of MIT, provided me with encouragement through intellectually sophisticated, yet down to earth, insight. I would also like to thank Mr. Eduardo Loayza and Dr. Lucian Sprague of the World Bank. Their trust enabled me to spend a short but productive summer in the World Bank. My long conversations with Dr. Sprague were critical in permitting me to write this thesis. As a reader of this work, he made comments that could only be conceived by a true fisheries development expert.

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INTRODUCTION

> Hence, detailed anticipatory knowledge of new developments through the economy might be required for any technicoeconomic choice.
>
> Anne Carter, 1970, p. 177

A basic planning problem is confronting Mexico. For over 50 years, the production of shrimp has been realized through traditional fisheries. As of 1970 and 1980, the maximum sustainable yield[1] of the gulf and pacific shrimp fisheries, respectively was reached. The limited production capacity that can be derived from the fishery defines the economic development that can be generated through this resource. However, the technology to farm shrimp, generally referred to as aquaculture or shrimp mariculture, has been developed and is available as an alternative technology to expand the production of shrimp from the traditional fisheries. Mexico has approximately 500,000 ha[2] of land suitable for shrimp farming (Secretaria de Pesca, 1987). Under average yields, the production from these farms may triple Mexico's shrimp production. Shrimp Aquaculture will eventually permit the expansion of the production of this product independent of the fishery.

The development of this new rural industry will have an important impact on the national and regional economies. To date, however no attempt

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[1]Maximum sustainable yield is the greatest yield that can be removed each year without impairing the capacity of the resource to renew itself (Lawson, 1984)

[2]Official estimates overstate the potential, a more realistic estimate is 250,000 hectares. Furthermore, considerations such as the prices of shrimp and energy may increase or decrease the economic feasibility of transforming the land to shrimp farms.

has been made at quantifying the potential economic impact of the implementation of a massive program of shrimp farm construction and operation. The most detailed published work has been by analysts who centered on partial equilibrium models (Banco de Comercio Exterior, 1988). These analysts tend to place emphasis on the very obvious primary impact of the activity, and they neglect the linkages that the activity has with the rest of the economic system. Indeed, the results from partial equilibrium analysis of development, while easy to perform, cannot provide the insight necessary for the formulation of long-term sectoral planning.

It is in the context of a general equilibrium model that we seek to answer two broad questions: What will be the economic impact on the Mexican economy of implementing this technology? What will be the economic impact on the regions where the development will take place? Although shrimp per se is the commodity that is fished, processed, and traded; the critical consideration is not that the supply of this luxury food--to those who can afford it--is constrained, rather it is that the economic activity that this fishery generates for the Mexican economy--is constrained by the natural resource endowment. Countries with developing economies, which by contemporary definition are not industrialized, and which hereafter will be called developing countries, oftentimes depend fully on the production of natural resource based goods. Although trade inequities in the form of relative prices contribute to a depressed economic performance (Prebish, 1984), the fact that the production derived from the natural resource base is finite, defines the boundaries of economic development based on the production of primary goods. For example, finite shrimp stocks define the production that can be derived from shrimp fisheries (Longhurst and Pauly, 1987).

Economic development policies based upon industrialization as the single stimulus for economic growth, are built implicitly on the premise that the natural resource base cannot be expanded or intensified. The regional potential of natural resources, in light of technological change, are oftentimes not considered as viable development strategies.

This thesis presents a case where the natural resource base of a country can be expanded and its productivity intensified through the implementation of new technology. In this way, the implementation of new technology generates production that supplements the production of the constrained resource. Supplementary innovation, the expansion of a primary goods sector through new technology, has peculiar planning implications.

CASE OF THE FOOD SECTOR

The most exemplary case of supplementary innovation has been the expansion of the production capacity in the food sector. For example, the expansion of maize and rice production in developing countries is the result of technological change. The green revolution, which promulgated the use of capital-extensive techniques and high yield varieties to produce grain, increased the value of the world rice harvest by $500 million (1981 dollars) (CIAT, 1981) and the wheat harvest by $2,500 million (1978 dollars)(CIMMYT, 1981). This technological and rural-industry revolution has been praised for its obvious positive effects (Per Pinstrup-Andersen and Hazell, 1985, in Gittenger, 1987, p. 108), and condemned for the nature and magnitude of the structural changes that it introduced into fragile developing economies (Hayami and Ruttan, 1985, p. 296, Calwell, 1984 in Gittinger, 1987 p. 166).

As we enter the 1990s a new technological revolution in the production of aquatic products is taking place, namely, the cultivation of aquatic organisms under controlled conditions. Today, aquaculture, represents 10% of the world production (volume) of fishery products (Fish Farmer International, 1989). The technology to produce aquatic organisms, independent of their natural environment, liberates the once supply-constrained industry. Indeed, according to the staff of the Food and Agriculture Organization of the United Nations (FAO), many nations have greater potential in the aquaculture of species than of fishery production (FAO, 1986). For example, the production of shrimp through aquaculture in 1970 represented less than 1% of the shrimp produced through the fisheries, today cultivated shrimp represents approximately 26% of the tonnage of the product placed on the market (Fish Farmer International, 1989).

One way in which economic development can occur is through technological innovation; however, the economic structural transformation of a sector, that is--the relative and absolute input mix required for the output of the sector--as well as changes in the social, environmental, and institutional framework, are issues that have not been systematically considered in the implementation of large investment programs in Mexico. Although social and institutional factors are critical, economic analysis may be quantified with greater ease and may lead into insights on the social and institutional factors in the "system" (Hirschman, 1958). The economic impact analysis required to understand, anticipate, and plan for technological change may be carried out at different degrees of complexity and using different units of analysis. The technique that has been used widely for developing a technicoeconomic choice has centered on the use of partial equilibrium models (Harberger and Jenkins, 1989). Partly due to the relative simplicity--in terms of execution and data requirements, partial equilibrium techniques of economic impact analysis have proliferated. These techniques has been adopted in the project and program appraisal as a legacy of the development planning that took place during the economic depression of the 1930s. Given the magnitude of the U. S. economy, partial equilibrium models were, from a national perspective, sensible. Indeed, these models are intended to be used in instances where the impact of the project or program is "small" relative to the economy (Rosen, 1985, pp 243-244). In the case of developing countries, the assumption that a program will have a relatively minor impact on the economy is not necessarily valid, thus rendering the partial equilibrium approach inappropriate for the analysis of large development programs. For the case at hand, the most critical omission in the use of partial equilibrium models is the consideration of the structure of the economy.

Thus, in order to provide a broader unit of analysis as well as considering the structure of the economy, general equilibrium models have been used. A partial equilibrium approach assumes that conditions in the rest of the economy are not affected by project or program development (Pearce, 1986, p. 333) implicitly neglecting the participation of other sectors in the production process. In contrast, a general equilibrium model, such as the input-output model, focuses on a sectoral production function that seeks to describe the relative participation of each sector in the economy in the production process of the sector being considered.

Thus, the general equilibrium model is said to have structural considerations while the partial equilibrium does not.

The simplest and most elegant of these models is the input-output model developed by Wassily Leontief in the late 1930s (Miller and Blair, 1985). There exists an important body of literature on the input-output model (Taskier, 1961., U.N., 1964, 1974) but perhaps the most relevant literature for the purposes of this research is the literature that focuses on the sectoral/structural attributes of the model.

In this study, we will focus on the need to develop a structural perspective in order to assess the economic impact of the implementation of a supplementary production technology. The need to understand the structural impact of technological change on a national economy has been studied by numerous authors (Bruno, 1962; Carter, 1970). The economy-wide, general equilibrium models employed by Bruno (1962) and Carter (1970) set the foundation for more detailed sectoral analysis by many analysts, such as Polenske (1989), Griffen and Jones (1975), and Strout (1967).

The sectoral approach in economic impact analysis using the input-output technique was perfected by economists, such as Leontief and Carter. Traditional measures of economic impact developed under the input-output framework have been used as policy models or as an important component in econometric models (Bulmer-Thomas, 1982). The limitations of the model as a prescriptive policy tool are generated by the underlying functional assumptions of the model.

The basic underlying assumption of the input-output analysis is the premise that a single-process production function exists in every industry (Todaro, 1971, p.20). From this basic assumption, two operational assumptions are generated. The first is that production of goods or services has constant returns to scale and a complementary assumption that no substitution among inputs is possible in the production of any good or service (Todaro, 1971, p.20). Thus, input-output assumes that a fixed and unique production technology is present in every sector. In addition, the premise of constant returns to scale is violated by natural resource-based sectors. These sectors have limited production capacities, and it is the introduction of technology (substitution of inputs) that permits the expansion of production. Indeed, this study, we simulate technological change by violating the assumptions of the model.

In research of comparative impact analysis of production technologies, a single characteristic, the inability of the model to account adequately for the formation and accumulation of capital, forces the analyst to propose a more comprehensive measure of the participation of the sector in the economic system. (Manne, 1963, Bulmer-Thomas, 1982 , Chen, Hao, and Xue, forthcoming). Analysts recognize that alternative techniques such as dynamic input-output (Carter, 1970: Taylor, 1975) overcome some of the limitations of the static input-output model, and the mathematical complexity and data intensivity of these techniques renders modified versions of the static model an important subject of study.

STUDY OBJECTIVES

The objective of this thesis is to ascertain the impact that the development of the shrimp aquaculture industry will have on the Mexican economy. To this end, we compare the impact that the shrimp fishery has on the Mexican economy with the impact of the production of the same value through aquaculture, as outlined in Chapter 5. The intersectoral aspects of the analysis are developed using a 1980, 93-sector/commodity Mexican input-output table.

A technical limitation of the procedure is the current account nature of the input-output matrix. The technique fails to account for the accumulated capital that permitted the current expenditures to take place. To illustrate, the input-output interindustry flows account for the diesel used in the fishery, but not for the diesel engine and the vessel, nor for any other capital equipment used in fishing. In order to develop a technique that accounts for the accumulated capital in the shrimp aquaculture industry, we developed a modified capital-stock technology vector using an assumption of a homogenous farm composition.

ANTECEDENTS OF THE INPUT-OUTPUT MODEL IN MEXICO

The input-output model has been used as a planning and evaluation model in Mexico since 1950. In that year the Banco de Mexico, Nacional Finaciera, and the Ministries of Programming and Internal Revenue; developed a 32-sector input-output table of the Mexican economy. In 1966, staff from the same institutions developed a matrix for 1960; however, they expanded it to 45 sectors. It was not until 1979 that the 1970 input-output matrix was made available to the public. This table was constructed independently by the Banco de Mexico. The 1970 Matrix was expanded to 72 sectors and followed guidelines of the U.N. System of National Accounts.

In 1983, the Ministry of Industrial Development constructed a 1975 table and the 1980 table was published by the Instituto Nacional de Estadistica Geografia e Informatica (INEGI) in 1986. This 72-sector table was later expanded by disaggregating the agricultural, forestry, and livestock sector into 24 commodities. This table, 93-sector/commodity table was published in 1988 as a joint venture between the ministry of agriculture and the INEGI. The United Nations Development Program participated in the construction and publication of the 1970 and 1980 matrices. For this study, we used the 1980 table which is the most recent and detailed input-output table publicly available of the Mexican economy.

FISHERIES SECTORAL MODELING

Although ample experience exists in sector and multisector model development, some sectors, especially apt for modeling purposes, have been neglected. For example, the fisheries sector is rich in bioeconomic analysis (Lawson, 1984); however, intersectoral relationships of the sector have not been considered. Indeed, fisheries development specialists blame the low rate of success of fisheries development programs of international agencies on the lack of awareness of the intersectoral impact of fisheries sector (Allsopp, 1985). Extensive general equilibrium modeling of the fisheries sector has only been executed and updated by industrialized countries. Detailed examples of this is the work done by Jordan and Polenske (1986) on the contribution of the Georges Bank fishery to the New England and Nova Scotia economies, and Griffen and Jones (1975) in the contribution of the shrimp fishery to the economy of the state of Texas.

Recent efforts of the United Nations Industrial Development Organization (UNIDO), using the Metodologia de Evaluacion Programacion y Gestion de Sistemas de Produccion y Cosumo (MEPS), have been undertaken to develop an empirical model of West African Fisheries (UNIDO, 1989).

Although this new initiative contains elements of a general equilibrium model, it does not account for how changes in the economy will have an economic impact on the fisheries sector and only partially accounts for the direct economic impact of the fisheries sector on the economy. However, the most significant contribution of the MEPS approach is the presentation of the internal structure of the sector, which permits refinement of the aggregate national accounts data.

The lack of empirical models to permit effective planning and evaluation of programs has been a major bottleneck in the appropriate development of the fisheries and aquaculture potential of countries with developing economies (FAO, 1986). Responding to this need, the World Bank, as the coordinating agency of a multiagency effort in long-term fisheries development planning, has prepared a five-point plan of action. One of the objectives of the program is to determine the feasibility of the design of empirical development models.

To date, the fisheries development planning that takes place is performed under great uncertainty. Indeed, after consulting with fisheries development specialists from the FAO and the World Bank, we have found that no multisector model--besides the recent UNIDO initiative--of the fisheries sector of any country with a developing economy could be identified. Thus, although we do not develop a sectoral model, we do attempt to provide an insight into the structural relationship of the Mexican fisheries sector, the shrimp fishery, and the impact of technological change in the production of shrimp on a national economic structure.

CHAPTER 2

QUALITATIVE COMPARISON OF SHRIMP AQUACULTURE AND THE SHRIMP FISHERY

> The disequilibria in economic relationships resulting from technical change represent a major source of institutional change . . . in some cases the demand for institutional innovation can be satisfied by the development of new forms of property rights . . . .
> Yjiro Hayami and Vernon Ruttan, 1985, pp. 94, 97

In order to formulate a quantitative analysis of the impact of the shrimp fishery and shrimp aquaculture on the Mexican economy, we must consider the qualitative factors that contribute to differentiate the two production technologies. Therefore, one of our objectives in this chapter is the presentation of a comparative framework of the most important institutional, social, and economic factors of the two shrimp production technologies. Given the wide scope of these topics, we limit the presentation only to those factors that contribute in a determinant manner to shape the economic structure of production. In Chapter 3, we present a strictly technical consideration of the differences in the production.

Our comparison of two technologies, one that is already in place, and one that is about to emerge, necessarily is based upon data that vary in quality. The historical data are replete of stochastic events that have shaped the sector. In contrast, the sector that is being forecasted for the purpose of comparison does not have historical precedent, at least in the location where it is being considered.

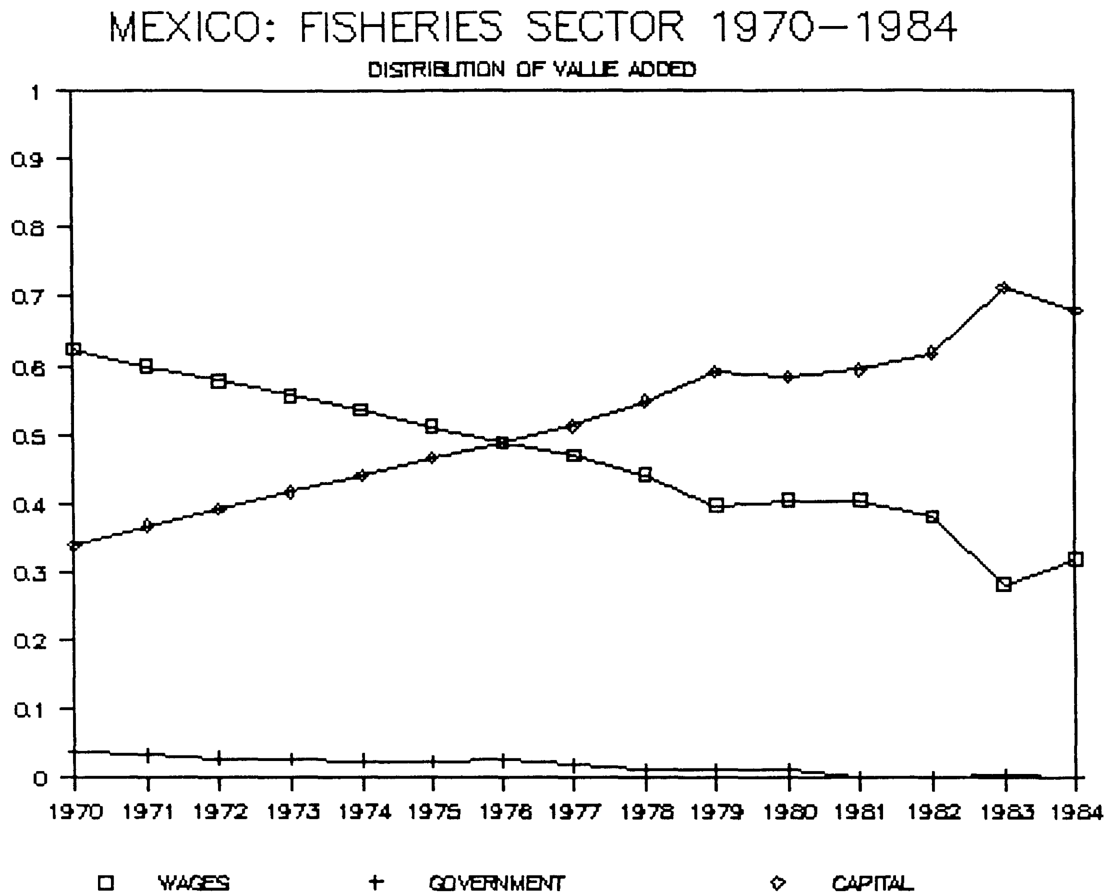
THE FISHERY

In general, the development of a fisheries sector in developing countries has had only moderate success (Allsopp, 1985). The Mexican case is no exception. Partly due to the nature of the sector as one that is easily misunderstood, at least in the political arena, the development of the sector tends to be motivated by political or social objectives without considering seriously the economic and technical factors. For example, the determination of fleet size has traditionally been set by political agenda rather than technical criteria. When fishery resources are abundant, the political objectives appear achievable; however, as the fisheries approach their maximum sustainable yield, policy blunders make themselves evident.

The Mexican fisheries sector had as its principal activity the shrimp fishery. With nearly 94% of the fishing vessels being shrimp trawlers (FONDEPESCA, 1985), shrimp has been, until the growth of the Tuna fishery, the most important fishery in Mexico. As such, the policies of the shrimp fishery tend to shape the sector.

From 1975 to 1985, the fishery sector went through a critical transformation. Indeed, this 10-year transformation is partly the reflection of the institutional composition of the sector. During this period there has been a complete reversal in the distribution of the gross production of the sector. Wages and salaries have dwindled in direct proportion to the gain in the return to capital, shown in Figure 1.

Wages and salaries in the cooperative sector are, by definition, a proportion of the profits of the cooperative. However, in an open-access fishery, where there is competition for the capture of the organisms, every new fisher into the system participates in the system by reducing the wages of all other fishers by an equal proportion. As such, expansion of the infrastructure did not lead to increased production, but rather to a reduction in the average wage received by those in the cooperatives. Meanwhile, as inflation increased, interest payments on the shrimp vessels



Source: Developed by author with data from
Secretaria de Pesca (1986)

rose to unimaginable amounts. On average, the per vessel production of each shrimp trawler was not even sufficient to repay loans. Exacerbating this situation was the tight institutional structure in which most payments had to be paid in-kind. This reduced the possibility of the fishers to receive cash income for their landings.

Other critical infrastructure, the processing industry, has suffered in a similar way. With a very high idle capacity, important investments lay idle accumulating public debt (FONDEPESCA, 1985). Clear evidence exists that the Mexican fisheries sector, like many other sectors in the world (Lawson, 1984), is vastly overcapitalized (FONDEPESCA, 1985). Thus, the historical perspective of the sector permits us to understand its economic structure as a manifestation of development policy rather than as the result of development that maximized private or public income.

AQUACULTURE

It is difficult to explain how a country that has ten percent of its production originating in aquaculture can be categorized as a "new" arrival to aquaculture. The most important issue to consider is that aquaculture has been defined in many ways. Indeed most of the approaches have been political rather than technical[3]. Clearly, Mexico's experience with aquaculture was until 1980 fairly minimal. It was not until aquaculture was seen as a strategy to expand the capacity of shrimp production that it began to be regarded as a viable rural industry. As

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[3]The formal definition of aquaculture is the production of aquatic organisms at densities above those found in the natural environment. Other more relaxed, but viable, definitions include any organism that has had at least part of its life cycle manipulated artificially.

such, little historical perspective can be placed in the analysis of aquaculture development. In addition, viable case studies are not available[4]. Any attempt to develop an idealized model of aquaculture development should, therefore, recognize the inability to measure political pressures or any other "stochastic" shocks.

INSTITUTIONAL FRAMEWORK

In this section, we will present the institutional framework of the fisheries and aquaculture activity. The institutional structure is the result of multiple factors among which, historical context, nature of the resource, and spatial distribution tend to dominate in the fisheries and aquaculture sectors (Salz, 1986). The most important manifestation of the institutional framework is the definition of property rights. In the case of the fisheries, the property rights are defined by the limited access of the fisheries and in case of the cultivation not only by access to organisms and their legal trade, but also by the ownership of land.

The Fishery

The institutional framework of the shrimp fisheries of Mexico is complex and runs parallel to the land reform impetus of post-revolutionary Mexico (Secretaria de Pesca, 1986). The fishery is not a pure open-access fishery. As such, the fishery is not open to any individual who is willing and able to participate in the activity. Since 1936, as a result of the unequal distribution in the ownership of the means to production in prerevolutionary Mexico, and concurrent with the political impetus for

[4]For example, the Ecuadorian shrimp farm development has taken place without a clear definition of property rights.

equity and regional development, the fishery was restricted to certified cooperatives (Secretaria de Pesca, 1986). The cooperativization of the most financially lucrative fisheries in the country (shrimp, lobster, oyster, abalone, totoaba, and turtles) affected the management practices and economic structure of the sector. During the initial development of the fisheries, the return on investment of these fisheries was very high. The lucrative aspect of the fishery stemmed primarily from the fact that most of its production was export oriented. More important is the fact that these fisheries represent the primary source of economic activity for many coastal cities; therefore, there was an implicit guarantee by the government and by the political constituency to support these activities.

The development of the fishery under a cooperative strategy led to important implicit and explicit subsidies (FONDEPESCA, 1985). Thus, an equity criteria, rather than an efficiency criteria, was the rationale for the structure and function of the reserved fisheries.[5] Clear evidence of the equity focus is the overcapitalization of extraction infrastructure, the non-optimal strategy of fish-trip management, and the subsidies in the form of preferential financing. Furthermore, institutional arrangements between the social sector and the government, such as the in-kind payment of loans through shrimp transfers, are unique and difficult to replicate in

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[5]The functional definition of equity does not imply an equalization of income or wealth. Rather, equity is bastardized to reflect the meaning of the word as is (was) used in a political context. Thus equity means the formulation of policy that generates a fragile legitimization of a one party system.

the private sector/government setting.[6]

In addition to the cooperatives serving as an instrument to attain social objectives, they serve as credit-receiving entities. The particular legal conformation of the cooperatives as limited liability entities has also affected the operation and development of the sector and particularly the shrimp fishery. Limited liability has precipitated an acceptance of risk in investment beyond that of an unlimited liability entity.

Political leverage has had a profound effect in shaping the economic structure of the extraction fisheries. The limited access characteristic of the fishery permitted the state to exert leverage on far-removed areas of the country. The privilege to fish came at the price of political allegiances. However, as the maximum sustainable yield was reached, the state no longer complemented the efforts of the organized cooperative sector. Additional fishers into the system reduced the return on investment made by the established cooperatives. Indeed developing seemingly unlimited natural resources under social objectives is easier than developing limited resources under social objectives.

Today, the federal government is rethinking the legal and economic structure of the primary sectors. The reality of an inadequate performance (output) of many of the primary sectors has precipitated actions such as the open nature of shrimp cultivation and the private participation in the

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[6]The social sector refers to organizations that are neither private nor public and have as their objective the welfare of the group of producers, consumers, or landowners that they represent. By contemporary lexicon, they would be grass roots organizations; however, they are "irrigated" grass roots organizations for they depend on the government for legitimacy, protection, legal stature, and oftentimes for financial resources.

mineral interests of Mexico. Indeed, the free market paradigm established primarily by the external financing agencies has become a part of the contemporary perspective of economic development in Mexico (Secretaria de Programacion y Presupuesto, 1987).

Aquaculture

The institutional composition of the aquaculture sector, until December 30, 1989, was very similar to that of the fishery. The usufruct of shrimp husbandry was reserved to certified cooperatives. However, a contradiction in the tenure of the land (with property rights held by persons or entities who could not legally produce shrimp) and the right to cultivate shrimp (held by landless fishers) made it inherently conflictive to structure shrimp cultivation cooperatives.

The institutional and legal contradictions were the result of the rigidity of the law with respect to technological change and how it may affect property rights. The husbandry of shrimp permits the country to go beyond the capacity constraint established by the natural resource. In effect, technological change permits persons to produce shrimp without affecting the stock of shrimp in the natural resource.[7] However, the law stipulated that the usufruct from the production of any shrimp was reserved to certified cooperatives.

Although it is important to consider the complexities of the institutional framework before 1990, for the purpose of this study the

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[7]The farm-raised shrimp will be effectively independent of the natural resource if the shrimps that are fattened in ponds are produced in laboratories. Under most strategies wild shrimp are used during the initial stages of the shrimp farm development.

institutional framework established after 1990 is more relevant. The modification of article 24 of the federal fisheries law permits the husbandry of any species by any person of Mexican nationality independent of their affiliation with a cooperative (Diario Oficial de la Federacion, December 30, 1989). The amendment of the national fisheries law, which opened the shrimp husbandry activity to the private sector, and even to international investment, permits us to make some important assumptions regarding the development of the sector. For example, the development of the shrimp aquaculture, will probably face no capital constraints; in addition, the development of the sector will take place under efficiency criteria.

Many important actors in the private sector are prepared to invest resources into the sector. The institutional structure of these private farms will not differ from the current structure of private agroindustrial interests. Thus, the role of the state will change from an entity that licenses the production of shrimp to the role as regulator of a free market and collector of taxes.

Implications of Institutional Framework

The primary difference in the institutional setting of the shrimp fishery and the cultivation of shrimp is that the former relies on social objectives, in that the fishery is based on cooperatives, while the latter, developed by profit-maximizing capitalists, is based on an efficiency criteria. The implications of this difference rests on how this institutional framework affects the economic structure of both production technologies.

The economic structure of both strategies, as manifested by the column vector of an input-output table, will be affected in a simple way. For example, the fishery technology vector represents a set of inputs that include the needs to fulfill the social objectives of the cooperatives; thus, it really is not a technology vector per se but a result of technology as well as public policy. In the case of the aquaculture vector, where efficiency is the primary objective of the production, the vector may more truly reflect the technological composition of production.

The probable institutional manifestation of the differences in the production technologies in the wages and salaries entry is of prime importance. Since cooperatives in theory are nonprofit entities with the return to equity being incorporated as returns to factors of production or reinvestment, we would expect the privately run, profit-maximizing firm to have less in wages and salaries but more in return to equity. In addition, the private firm, given its freedom of scope in operation, may more easily move towards vertically integrating, thus reducing its reliance on other sectors.

The interpretation of the institutional implications of cooperativization of an overcapitalized sector can be explained in part by Figure 1. The inverse relationship between wages/salaries and return to capital may indicate that as the sector is overcapitalized, the wage level decreases.

MARKETING OF THE PRODUCTION

The marketing of shrimp, comprised of the transportation, processing, packaging, and sale of the product, corresponds to the forward linkage components of the activity. A critical consideration is the prevalent type of processing as well as the conditions under which it takes place. An important idle capacity exists in the processing sector (FONDEPESCA, 1985). Thus, an expansion in production and a subsequent increase in the demand for processed shrimp would require more capital investment; therefore, we only need to consider the current account forward linkage.

The Fishery

The marketing of the production of shrimp in 1980 was 85% as frozen headless shrimp. Frozen shrimp requires a capital-intensive process, which involves large amounts of energy, capital infrastructure, and paper products for the final presentation as 5-pound headless blocks of shrimp. The principal input is energy, as the production must be maintained in specialized cold storage rooms. Other presentations of the product, include heads-on shrimp for domestic consumption and dried shrimp. Thus, although the majority of the production goes to the export market as frozen shrimp, part of the production does remain for domestic consumption.

Aquaculture

Aquaculture crops, such as shrimp, are rarely produced in developing countries for the purpose of domestic consumption (Lawson, 1985). Indeed, although the natural growth of the population does permit the introduction of more shrimp to domestic markets, the inelastic supply (historically) and high production cost--combined with the skewed income distribution--Mexico, has limited the growth of the domestic market for shrimp.

Thus, it is safe to posit that most shrimp are destined for export markets. Indeed, all financial projections of shrimp production are based on the international wholesale price rather than domestic price. Given that the export market is restricted to two primary presentations, individually quick frozen (IQF) and--the predominant unit of trade in shrimp marketing--, five-pound headless frozen block, the processing and marketing channels are predetermined.

Implications of Marketing Strategies

One of the most important implication regarding the marketing differences of the fishery shrimp and the aquaculture shrimp rests on the definition of the forward linkages with the rest of the economy. The fact that part of the shrimp fishery is destined for domestic production, implies that the hinterland transportation, wholesale and retail sale, preparation in restaurants and other establishments, will represent important forward linkages. Additionally, the diversity in the presentation of the product, such as dried, represents important sources of employment for specific towns.

In contrast, the aquaculture production of shrimp will be exported in the presentations that have long shelf life and multiple end uses: either frozen blocks or as individually quick frozen shrimp. The transportation of the product will be international in nature, thus having linkages outside the border. Finally, the wholesale characteristic of the marketing, eliminates any retail trade generated linkages. Although we know that the forward linkages are important in evaluating the economic impact of aquaculture, we are unable to treat them in this study, but we recognize that the impact of producing shrimp for the export market rather than for domestic consumption may be fairly different.

CHARACTERISTICS OF THE PRODUCTION

The shrimp produced under the two production technologies is of the same organoleptic characteristics. However, an important difference, the size of the organisms, is relevant in analyzing the economic impact of technological change.

The Fishery

An important characteristic of the production of the wild fishery is the species produced and the size of the organism produced. The Mexican shrimp fishery depends primarily on five species of shrimp. Each species, or group of species, commands a given price in the international market. Thus, the output produced by the fishery depends on the relative composition of the shrimp produced.

Another critical factor is the size of the organism. The price that shrimp command is directly related to the size of the shrimp (measured in number of shrimp tails per 454 grams (one pound). The shrimp from the shrimp fishery have a wide range of sizes and consequently a wide range of prices. The jumbo shrimp (12 per pound of "U-12") command a much higher price than the medium shrimp (30 per pound or "U-30".

Finally, a critical consideration is the quality of the shrimp produced. If we accept the historically high price of the Mexican shrimp as a proxy for the quality of the product, then we can assume that the Mexican fishery has traditionally produced the highest quality shrimp (of its species) in the world (Finne, 1990). This is due to the short duration of the trips made by the vessels and the short storage time of the shrimp, prior to final processing, in the refrigerated hulls. Although the short duration of the trips is not a predetermined strategy, but rather a response to provide the fishers with a shorter time away from their families, the end result is the excellent reputation of the Mexican shrimp.

Aquaculture

The aquaculture production of shrimp differs in the three points considered above. Aquaculture production is primarily focused on one species (P. vanemmei) and less so on a second (P. stylirostris). Thus, the production is not based on a great number of species. With regard to the size of the organism, aquaculture production produces a more homogenous grouping of shrimp. No jumbo shrimp are produced through standard cultivation practices. Similarly, the number of small shrimp produced is limited. The quality of the shrimp produced through aquaculture is equal to or superior to that of the fishery. Because the shrimp are taken from the ponds and are processed immediately afterwards, the visual and organoleptic characteristics are impeccable. Additionally, since shrimp may be shipped alive in trucks, specialized markets of live or fresh shrimp can be targeted.

Implications

The fact that the aquaculture production rests on fewer species than the fishery, which command the highest export prices of any shrimp in Mexico, favors the production of aquaculture shrimp over that of the wild fishery. With regards to the size of the animal produced under both technologies, the aquaculture techniques presently find that the lack of diversity of the product (homogeneity of size) makes the industry vulnerable to changes in the market. Indeed, the flooding of the market of one size of shrimp has been seen by marketing experts as a real danger. The price formation of the shrimp produced on the American continent is based on the relative scarcity of one size of shrimp over another. Thus, a comprehensive comparison of the two production technologies would have to take into account the impact of the elasticities of supply and demand for each size shrimp in the formation of the price.

Regarding the third observation, the quality of the product, the windfalls of having a tradition of high quality wild fishery shrimp will help the Mexican aquaculture shrimp to maintain a quality markup in international markets (FONDEPESCA, 1987). Thus, although both technologies produce shrimp, subtle but important differences determine the characteristics of both strategies.

RISKS

The significance of qualitative factors can best be understood by the role they play in shaping the sector. We have chosen to examine this issue by placing it in a framework of assessing the uncertainties involved in the two production strategies. Furthermore, we consider the interaction of the fishery with aquaculture.

In this study, we simplify the analysis by assuming that there is independence between the two production processes; however, in most cases this is a very strong assumption. There is a complex interaction between the aquaculture of shrimp and the shrimp fishery. Socially, the structure of rural employment is affected by the growth of the aquaculture industry.

In 1987 there were more than 50,000 fishers that switched from their normal "market fishery" to landing shrimp post-larvae.[8] This disorganized and unregulated extraction of post larvae is seen as one of the principal factors in the reduction of the marine shrimp fishery.

Another factor that brings the two production strategies into conflict is the destruction of mangrove forests. In 1987, it was estimated that half of Ecuador's mangrove forests had been destroyed by the constuction of shrimp ponds (Longhurst and Pauly, 1987). The mangroves, which provide organic matter to juvenile and post larval shrimp, play a critical role in the ecology of the coastal waters. Indeed, there is direct relationship between organic matter discharges and shrimp production (Longhurst and Pauly, 1987). The conflict that arises, between shrimp aquaculture and shrimp fisheries, from the destruction of mangrove forests is a critical consideration. Indeed, if the growth of shrimp aquaculture is not mangaged with sustainable long term ecological considerations, then it is reasonable to expect the fishery to suffer.

A final example of the interaction of aquaculture and the fishery is the pollution generated by the shrimp farms. Organic and inorganic fertilizers are added to the ponds in order to maximize their natural productivity. This nutrient rich water is flushed into the estuaries polluting the fragile ecosystem.

We have listed some of the principal conflicts that arise between the two production technologies. Although it is difficult to isolate the

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[8]Shrimp post-larvae are the small shrimp that are stocked in the fattening ponds. The post-larvae may be produced in a laboratory or may be extracted from the shrimp breeding waters.

effect of any particular conflict, it is our objective to point out the complex nature of the production technologies. The risks generated through the implementation of aquaculture are not to be disregarded. Indeed, in any given region there may be an appropriate balance between aquaculture development and the fishery.

CONCLUSION

Qualitative factors contribute in differentiating the Mexican shrimp fishery from shrimp aquaculture. In this sense, the interaction of the institutional structure and the property rights shows that there are distinctions between the two production technologies. The restriction of the shrimp fishery to the cooperative sector and the recent constitutional amendment opening up the cultivation of shrimp to any Mexican citizen will determine the future development of both technologies and the economic impact that they will have on the Mexican economy. The institutional structure specifies not only who benefits from the resource, but also the organization of work, the distribution of wages, return to capital, and transfers to the government. In short, the institutional framework determines the value added of the sector.

Other factors, such as the characteristics of the output and the marketing channels, shape the production strategies. Although these factor clearly influence the sector, we believe that there are other less apparent but more significant, qualitative considerations. For example, the temporal nature of the linkages of both production technologies contribute to an irregular demand for labor and a tendency for infrastructure to be over scaled. These two factors lead to disruption in the employment pattern of the rural sector and to capital investments that are vulnerable to any changes in the economy.

Finally, the risks associated with the implementation of shrimp aquaculture should not be overlooked. The problems generated through the implementation of aquaculture may be solved trough planning (Salz, 1986). Organizational approaches in reducing institutional and economic conflicts of aquaculture development have been taken in carp culture in India (Sprague, 1990). A proposal of a similar nature by Vergara (1987) to structure the shrimp farm development as industrial parks has been implemented in a pilot basis in the sate of Sonora. Indeed, Hayami and Ruttan (1985) believe that technological inovation is a principal factor in the definition of institutions and, in turn, the structure of production.

Chapter 3

TECHNICAL ANALYSIS OF THE SHRIMP FISHERY AND SHRIMP AQUACULTURE

In this chapter, we review the technical aspects of the industrial fishery and aquaculture-based production of shrimp. We separate the presentation of the technical aspects into three sections: infrastructure (capital expenditures), operation (current expenditures), and the actual production process, focusing the discussion on the concepts that are salient to the economic impact analysis. The material in this chapter is based principally on two documents and on professional experience of the author as a fisheries planner. The principal document for the shrimp fishery (FONDEPESCA, 1985) was developed by a multidiciplinary team of professionals at FONDEPESCA. One of the principal objectives of this documents was to establish a technical foundation for the capital investments required in the industrial shrimp fishery. The basic reference for the shrimp aquaculture is a practical production shrimp production manual (FONDEPESCA, 1988). This state of the art document was prepared by the French paraestatal France Aquaculture for the FONDEPESCA.

PRODUCTION POTENTIAL

An important issue that defines the technology of production of the fisheries and aquaculture strategies is their level of development. The fact that the fishery has reached its maximum sustainable yield implies that the expansionary phase of its development has been completed. Thus, capital inputs into the sector reflect primarily the renovation of the capital stock. In this framework, the capital expenditures required for the aquaculture sector differ dramatically from those of the fishery.

The production potential of the sector is vast, and capital expenditures correspond to the construction of new infrastructure.

INFRASTRUCTURE

The most important difference in the capital expenditures of the production technologies is the infrastructure. Of particular relevance is the spatial distribution of the investment and the impact that it may have on a region. In addition, the inputs into the two technologies differ considerably. The specialized nature of ship construction relative to the earth movements that must take place in the construction of shrimp farms has important implications concerning the utilization of excess capacity in the construction industry. Another critical consideration is the life of the infrastructure and its maintenance requirements. The linkages associated with the maintenance of the infrastructure is a critical consideration in presenting a comparative framework.

The Fishery

The Mexican industrial fishery of shrimp can be divided geographically into the Gulf of Mexico fishery and the Pacific fishery. The development of the Gulf fishery was influenced substantially by the development of the fishery in Texas. Thus, in the early stages of its development, the vessels and extraction gear used were of U.S. design. During the 1960s, while the Mexican fleet remained primarily composed of wooden vessels, the U.S. fleet began to change to steel-hulled vessels. The Pacific fishery, with almost two times the landings of the Gulf fishery, has had a more autonomous technical development. Indeed, the evolution of the design of the modern Mexican shrimp trawler, a 72-foot, steel-hulled trawler, has some important differences with the U.S. homolog. For the discussion of the fishery infrastructure, we will present two principal units of analysis: the aggregate 1980 mexican shrimp fleet and the 72-foot vessel that has become the standard vessel in the fishery.

The 1980 Mexican industrial shrimp fleet was composed of 2,783 vessels of diverse specifications. The fact that the fleet is the result of a build up of over 20 years contributes to the heterogeneity in construction material, import content, and cost of capital. Three of the most relevant variables that define the characteristics of the fleet are the age of the vessels, the material of hull construction, and the horsepower of the engine. The first two quantitative measures are relevant in determining the operating costs of the fishery, while the third is important in the linkages that the construction of the vessel will have with the rest of the economy.

The size of the fleet under operation is also affected by relative prices of maintenance inputs and by the exchange rate with respect to the North American dollar. Data on the actual number of vessels operating during 1980 are not readily available; however, traditionally all calculations regarding the performance of the fleet are generated using standing-fleet, rather than operating-fleet, data.

The spatial distribution of the fleet provides a framework by which the impacts of the fishery are spatially distributed in the country. An important consideration in the spatial distribution of the fleet is that given the industrial nature of the vessels, the services rendered to them are concentrated in ports; therefore, the economic impact is not usually distributed over a region.

Aquaculture

The infrastructure required for the husbandry of shrimp differs dramatically from the fishery. The homolog of the hull of the vessel is the levees that conform the cultivation ponds. In addition, the homolog of the shrimp vessel fleet is equivalent to the number of shrimp farms constructed. Because in 1980 no commercial shrimp farms were built, in this study we will assume that there were 1200 shrimp farms with a total surface area of 90,000 hectare.[9] Given that the potential shrimp farming capacity of Mexico is greater than the required assumption, the assumption is well within the realm of a probable long-run development. We analyze the three major components of the infrastructure: levees, pumping stations, and power sources.

The levees are constructed by accumulating soil with high clay content and forming a trapezoidal structure. These structures may be typically built by standard earth-moving equipment such as backhoe and caterpillar bulldozers, which are imported from the United States. Another important component of the farm is the pumping station. Because shrimp require that up to 20% of the volume of the water in the pond be changed daily, the pumping station constitutes a major expenditure in the infrastructure of a shrimp farm. The engines that propel the pumps may be driven by diesel fuel or electricity; however given similar operation

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[9] 90,000 hectares are the number of hectares needed to produce an output that matches the production of the fishery. We have assumed that each hectare will yield 511 kilograms of shrimp per year.

costs, operators of farms prefer the more reliable and efficient electrical engines.

Given the rural setting of the shrimp farms, the network of rural roads and rural electrification represent important positive externalities of shrimp farm development. An important consideration is that the capital invested in these roads will be from the private sector, thus not be a burden on the government. In summary, the major infrastructure components of aquaculture production are the construction of levees, the pumping station, and the power source for the pumping station.

OPERATION OF THE INFRASTRUCTURE

No reliable aggregate data on the inputs used in the operation of the 1980 shrimp fleet are available; however, annual data on per vessel inputs per year are available and serve as the base we use to estimate the input requirement of the fleet. The inputs required per vessel are directly related to the number of fishing days per year. It is important to note that the fixed costs of operation, including the payment of debt, typically represent over 40% of total costs. Indeed, the economics of vessel operation differ from traditional agricultural economics, given the need to cover large fixed costs (Lawson, 1984).

In Chapter 5, we show the inputs required to operate the Mexican fishing fleet. Given that these calculations are based on average input requirements, we must also generate factors for each component in relation to the type and age of the vessel. The inputs reflect a homogeneous factor of production, and the fleet will probably approximate this composition by the year 2000; therefore, this analysis is relevant for historical and forecasting purposes.

The operation of the aquaculture infrastructure resembles the operation of an energy-intensive farming operation. The two primary inputs are energy and manufactured feed. We calculated the energy requirements of a typical shrimp farm calculated as horse power-hours required per year of production. We then estimated the relative efficiency of diesel engines and calculated the yearly energy requirement for the production of the shrimp.

The feed requirements of a semi-intensive shrimp production represent the most important input, in terms of value, in the production of the organism (Allen, et al., 1984). Given that feed-biomass conversion factor in shrimp culture have typical values between 1.8 to 3.0, depending on the environmental conditions, husbandry practices, and quality of the feed, a value was chosen from personal experience and the total feed requirement was calculated. Other inputs, such as labor, maintenance, transportation, and management costs, were also considered and are summarized in Chapter 5 in terms of operation inputs for a single farm and for the stock of farms.

PRODUCTION PROCESS

Conceptually, the production technology may be thought of as the use of infrastructure (capital) through the introduction of production inputs (current expenditures). In this section, we briefly discuss the production technology, again attempting to highlight the aspects salient to the comparative analysis of the impact that the production technologies have on intersectoral transactions.

The Fishery

The nature of the shrimp fishery revolves around cycles. In the Gulf of Mexico, the cycle is principally climatological, and in the Pacific fishery, it is biological. The Gulf of Mexico shrimp fishery has a relatively constant growth in its population and biomass; thus, the management of the fishery does not require that a fishing season be instituted. However, the rough seas during the winter months makes it impossible to fish (FONDEPESCA, 1985). In the case of the Pacific fishery, the reproductive cycle of the shrimp is very pronounced; thus, the appropriate management strategy is to institute a fishing season.

The implication of the cyclical nature of the shrimp fishery in Mexico is the cyclical nature of the linkages with the rest of the economy. Demand for goods and services is not constant throughout the year; thus, the economic structure provided by the fishery must be complemented by other activities. Although in some cases a cyclical operation may be desirable, this phenomenon leads to underutilization of infrastructure, particularly in the forward linkages, such as processing.

Another characteristic of the fishery is its relatively high labor requirements; for example, although an equivalent U.S. vessel is operated by three persons, the Mexican vessel has six persons (FONDEPESCA, 1985). Given that the crew is paid according to a percentage of the value landed, the equity implications are important. Although the benefits of having important landings are shared among the crew, the miseries of poor landings are also shared.

The nature of the fishing process, in which the vessel drags the two side nets for a period of typically 20 to 40 minutes, provides landings that are handled by the crew without trouble. Every shrimp that is to be processed as frozen tails is handled by the fisher, and the head is removed before it enters cold storage in the hull. Because the storage room is filled in 2 to 3 weeks at a minimum, the work of removing the heads is spread over that period. No extra labor is required.

Aquaculture

The production process in the cultivation of shrimp under a semi-intensive open and closed system of production is as follows. The major difference between the closed and open system of production is the source of the shrimp post-larvae (the juvenile shrimp that are fattened in the ponds). Under the closed system of production, the farm either produces or purchases shrimp post larvae that have been reared in a laboratory. The ability to purchase the post larvae gives the farms an important production flexibility. The manager is able to schedule the production in order to meet the production strategy of the farm. Farm managers, for example will be able to arrange a reduced processing fee during the period of time when the fishery is closed--when the processing plants lay idle. This arrangement provides an opportunity to exert leverage over an otherwise monopsonistic industry.

Another advantage of the laboratory reared post-larvae is that it eases the quality control of production, primarily through disease-free certification as well as by being able to quantify the organisms carefully. Both attributes are impossible to attain with the wild Post larvae. The production of shrimp post larvae is a complex and expensive endeavour. It demands a skilled and disciplined cadre of technicians. Today, in Mexico there are enough persons with advanced training in shrimp culture to form the nucleus of such groups. Detailed explanations of larval rearing of penaid shrimp exist (McVey, 1983); however, few financial analysis exercises have ever been published (Fondepesca, 1988). Although an economic analysis of the growth of the shrimp farming industry should include considerations of the construction and operation of the laboratories, in this study, we will restrict its analysis to the operation of the farm itself.

The actual growout or "fattening" procedure under both the closed and open cultivation systems is similar. The semi-intensive technique relies in the use of the ponds of between 2 to 10 hectares in surface area. The shrimp are introduced into the ponds and are fed daily. Daily water exchanges of between 2 to 20% of the total volume are required for maximum growth. The growth of the shrimp will be, on average, 1 gram per week. From an intersectoral perspective, the critical consideration of the pond rearing is the important demand that is generated for feed and energy.

CONCLUSION

The fishery-based production technology has important differences with the aquaculture production of shrimp. From an economic development point of view, we must consider the linkage profile generated by the capital and current expenditures of both technologies. Furthermore, a consideration of the cyclical nature of the fishery and its impact on the linkages with other industries, as well as the difficulty in the definition of the optimum scale of the service infrastructure, contributes to the structure of the fisheries industry. In contrast, an aquaculture-based production provides the opportunity for the development of a production with coordinated harvests, thus permitting a fuller utilization--both in time and capacity--of production infrastructure and goods and services provided by other sectors of the economy.

CHAPTER 4

STRUCTURAL FRAMEWORK: LINKAGE ANALYSIS

> Are not the Hirschman paradoxes a joy when spun by the master, but dangerous in the hands of mediocre followers, hence to be labeled poison?
> Carlos Diaz Alejandro, 1984, p. 113

The objective of this chapter is to present the concept of linkage analysis. Linkage analysis provides a quantitative framework for measuring the participation of a given sector in an economic system. This framework is particularly appropriate in the initial phases of sectoral planning. Through linkage analysis, analysts can do development planning of a sector by considering the economic structure within which the sector will grow. Although sectoral planning through linkage analysis was initially intended to define key sectors in an economic system, analysts may also use it to develop an indicative framework of the impact of a development policy or of technological change.

Traditional fisheries studies present the economic system from the perspective of the fisheries sector. This partial equilibrium ideology in the analysis of a sector has resulted in an incomplete assessment of the role that the sector plays in a regional or national economy. Although this narrow view of the sector may perhaps be sufficient for the implementation of small projects within the sector, it does not provide the necessary insight for large programs such as modernization or the implementation of a new technology. As we argued in Chapter 1, a general equilibrium approach may fulfill the analytical requirements more fully than a partial equilibrium approach. Within a general equilibrium approach, linkage analysis serves as the analytical instrument to quantify the structural features of the economic system and of the sector under study. Clearly the limitations of the input-output framework, which stem from the assumptions of the model, are transmitted to any detailed analysis, such as linkage analysis. Furthermore, linkage analysis itself has been subject to severe scrutiny during recent years (Skolka, 1986). Even considering the limitations, linkage analysis does serve to provide a richer indicative framework for planning sectoral development than the partial equilibrium perspective.

In short, linkage analysis enables analysts to consider the fishery sector from the point of view of the economy, contrasting radically from the perspective of the analysis of the sector as a part of the national economy. This latter perspective is only justified in island countries and a few East African countries where fisheries contributes more than 10% of the gross national product.

THEORETICAL FRAMEWORK

The concept of linkages and their role in economic development were first put forth by Hirschman (1958) in his classic The Strategy for Economic Development. The concept was simple, there exist (or can be created) sectors in an economic system that given their position in the structure of the economy, influence the performance of other sectors. Specifically, Hirschman (1958) defined an input and an output structural phenomena that served as inducement mechanisms for the directly productive sectors.

The two mechanisms, forward and backward linkages, form the basis of many of the current economic development strategies. The backward linkage was defined as "The input-provision, derived demand, or backward linkage effects, i.e., every nonprimary economic activity, will induce attempts to supply through domestic production the inputs needed in that activity." (Hirschman, 1958, p. 100) With this definition, Hirschman posited that certain sectors generate a demand for goods (and services) that may be filled by other sectors of the economy.

Certain sectors, however, serve not as the generators of demand and subsequent economic activity, but as suppliers of demand, or as Hirschman wrote: "The output-utilization or forward linkage effects, i.e., every activity that does not by its nature cater exclusively to final demands, will induce attempts to utilize its outputs as inputs in some new activities" (Hirschman, 1958, p. 100). Indeed, if the backward linkage is considered as "induced demand," it might well be appropriate to refer to forward linkages as "induced supply."

PRACTICAL IMPLICATIONS

The identification of forward and backward linkages in an economic system serves as the foundation of economic development theory. For empirical research, linkage measures permit the allocation of scarce resources by identifying the location in the economic structure that would generate the greatest stimulus to the economic system. In addition, through linkage analysis, analysts are able to identify economic relationships that would be difficult, if not impossible, to identify by just conducting a survey of the inputs and the outputs of the sector. Thus, as applied economic analysts, we find that the implications of the forward and backward linkage concepts are important considerations in the formulation of sectoral development policy.

Implications of Backward Linkages

Backward linkages, or as Hirschman astutely called them "derived demand," have important implications for development planning. Because "backward linkages show the relationship of interindustry purchases to total purchases," the linkage will indicate the presence of supporting economic activity derived from that sector (Polenske and Sivitanides, forthcoming). For example, in the fishing industry, principal backward linkages would be with the steel industry (hull of vessel) and engine manufacturer (engines) as related to capital inputs, and petroleum (diesel fuel) in the current account inputs.

The implication of the backward linkage is that within the confines of economies of scale and comparative advantage, it can be advantageous for a region, country, or union of countries to internalize the benefits of induced economic activity generated from investments in sectors with large backward linkages. Indeed, Stewart (1972) considers linkages in the realm of market failure, for they are externalities that fail to be captured in the market price of goods and services and thus in the decision-making process of sales and purchases. Two important policy implications of considering backward linkages as internalizable externalities may be identified. The first refers to a sectoral approach to development planning (key sector) and the second to the formulation of national development policy (import substitution).

As quantitative measures of intersectoral trade, the premise of identifying sectors that have large backward linkages and concentrating resources on those sectors translated to a "key sector" ideology. Hirschman (1958) posited that the identification of key industries using a linkage ranking could contribute as an analytical tool in the formulation of development policy (Hirschman, 1958 p. 108). These key sectors, exemplified by the steel industry, serve to induce economic activity in other sectors. The significance of defining the sector as the unit of analysis is the basis for the development of the unbalanced growth theory.

From a national economic planning perspective, the concept of linkages served as a factor in the implementation of the import substitution strategy. Indeed, Hirschman (1984) later reflected on the merits of the key sector/unbalanced growth approach as one that permits economies to grow outside the pattern established by the modern industrialized nations.

Implications of Forward Linkages

The forward linkage shows the relationship of interindustry sales to total output (Polenske and Sivitanides, forthcoming). In this way, the forward linkage is an indicator of the transformation that the product produced by any given sector undergoes. For example, in industrial fisheries the major capital forward linkages might be processing equipment and the transportation of the product to the wholesale and retail markets.

Forward linkages have received less attention than backward linkages (Bulmer-Thomas, 1984; Hirschman, 1984). However, the concept of generating income and employment through internalizing transformations to the primary products produced in the rural sectors is gaining attention. The forward linkage is a relevant issue with primary export economies. Packaging and physical transformations have been an impetus in large industrial endeavors as well as in the promotion of microindustries. For example, in 1988 the Mexican government began a program to educate small producers regarding the benefits of adding value to the primary products that they produce by packaging of oysters in a package for final retail sale, the smoking of trout and oysters, and the filleting of fish, all of which represent adding value to the product that accrues to the producer. Indeed, these transformations are forward linkages that would take place by an intermediary. By capturing the benefits of this forward linkage, the small producer may increase his/her income without having to expand physical production.

In the industrial fisheries the forward linkage through processing represents an important opportunity to generate income. Primarily due to political factors, however, countries continue to export fairly low value added fishery products. For example, the Mexican shrimp resource lends itself to vertical integration in the preparation of frozen precooked dishes, i.e, "TV dinners." However, that type of high value activity has been reserved, through lobbying pressure, to U.S. producers.

MEASUREMENT OF LINKAGES

The nature of economic linkages, as defined by Hirschman, is critically dependent on the structure of the economy. The structure of the economy will be dependent on the human, natural, and capital resources that the country holds. These three components, are amalgamated by the technology of production used. As Hirschman himself identifies, the "unit" that links the sectors are inputs and outputs.

Although linkage analysts use inputs and outputs as units of analysis, they traditionally base the unit of measurement on the value rather than the physical unit. In this way, the technical relationship is translated into what Carter (1970) refers to as technicoeconomic relationships. Although the traditional interpretation of linkages from economic theory has focused on an economic perspective; linkage analysis, according to Hirschman (1984, p. 98): ". . . almost compels one to consider the interaction between the social structure and the state, on the one hand, and the more narrowly economic factors in the other." Nonetheless, economic analysts have measured linkages as purely economic phenomenon, and others must derive the social and institutional implications from these economic results. The fact that sectors contribute either as suppliers (input) or purchasers of goods and services (output) in an economic system can be quantified in an input-output framework.

The simplest measure of the backward and forward linkage is the direct backward and forward linkage. Conceptually, the direct linkage is the "one time" purchase and sale of goods and services from a sector to a given sector. Thus, this measure of linkage could be considered to be the short-run repercussion of the activity in the sector being studied. The direct backward linkage is measured as the column sum of the A matrix, and the direct forward linkage is measured in the input-output framework as the row sum of the B matrix (Miller and Blair, 1985, pp. 323-24).

A richer linkage measure is the total or overall forward and backward linkage. Conceptually, the total forward and backward linkage is the summation of the purchases or sales by the sector under study to the other sectors in the economy. This measure considers not only the initial or "one time" purchases and sales, but also the secondary, tertiary, and later purchases and sales. Thus, the total linkage takes into account the long-run repercussion of the initial economic activity and is not confined to "first-round" effects. The measurement of the total backward and forward linkage is the column sum and the row sum of the (I-A) and (I-B) inverse matrix, respectively (Leontief, 1966).

An important consideration in linkages with respect to developing economies is the nature of the backward linkage. For example, if the backward linkage results in an increase in the quantity demanded of products not produced by the national economy, then the imports generated by this linkage result in leakages out of the economy. In terms of the backward linkage (excluding imports), the relevant measure is the column sum of the (I - A + M) inverse (Polenske and Sivitanides, forthcoming). The difference between the total and the net backward linkage is the linkages attributable to imports. This captures the level of dependency of the sector on imports (a measure of the propensity to import). Another issue to consider in the interpretation of the linkages is the capital intensity of the linkages. Bulmer-Thomas (1982, p. 195) posits that sectors with high backward linkages have a high dependence on intermediate goods that are typically capital intensive; thus, the high backward-linkage sector may be theoretically desirable, but impractical, to attain in capital-constrained economies.

The calculation of the total forward linkage may also be refined in order to consider the "value added foregone". For example, a classic problem in economic development is the unequal terms of trade of nations with developing economies. In many cases, the unequal terms of trade is attributed to the export of "raw" material. These raw products enter the economies of the importing countries where the products undergo a series of transformations. In effect, the linkages that are generated by this product theoretically could have been captured in the developing country. Thus, even though the country may not possess the necessary infrastructure to transform the product, it is interesting to estimate the "value added foregone" in terms of "linkages foregone". Indeed, although the value added forgone represents resources that are escaping out of an economy, it also represents unrealized potential of an economic system.

POWER OF DISPERSION AND COEFFICIENT-OF-VARIATION MEASURES

The measurement of the strength and dispersion of the linkages of one sector over other sectors in the economy is important in order to define more precisely the impact of the sector under study with respect to the rest of the economy. A technique developed by Rasmussen (1957) permits us to establish a measure of the influence of a given sector relative to the average total stimulus "linkage" in the economy (Bulmer-Thomas, 1982, p. 191). This measure, known as the power of dispersion "shows the relative extent to which an increase in final demand for products of a sector are dispersed throughout the system of sectors" (Polenske and Sivitanides, 1990).

$$\frac{(1/n) \sum_{i=1}^{n} c_{ij}}{(1/n^2) \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij}}$$

rij denotes element i,j of the Leontief inverse.
n denotes the number of sectors.
the numerator denotes the average stimulus imparted to other sectors by a unit's worth of final demand.
the denominator denotes the average stimulus for the whole economy when all final demands increase by unity.

When the measure is greater than one, it implies that the sector being analyzed yields above-average (for the economic system) backward linkages, while results less than one mean that the sector yields below-average, economy-wide backward linkages.

The same principle may be used to characterize forward linkages; however, in the case of forward linkage, the measure characterizes the ability of a sector to influence the economy as it makes inputs available to other sectors. The formula for the forward linkage power of dispersion is similar to that of the backward linkage; however, it includes the row sums of the (I-B) inverse matrix rather than the column sums.

$$\frac{(1/n) \sum_{j=1}^{n} c_{ij}}{(1/n^2) \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij}}$$

rij denotes element i,j of the Leontief inverse.
n denotes the number of sectors.
the numerator denotes row sum i of the Leontief inverse which in turn measures the total impact of sector i when final demand for all sectors increase by unity.

Another relevant linkage measure is the coefficient of variation for backward and forward linkages. In the case of the backward linkage, this measure estimates the extent "to which a given sector draws evenly from other sectors." Thus, the planner can determine the participation of the sector under study in the economic system. In the case of the forward linkage, the measure estimates "the extent to which the system of industries draws evenly upon the given sector" (Polenske and Sivitanides, forthcoming). Thus, the planner can determine the interaction of the economic system with the sector under study.

The formula for the coefficient of variation of backward linkages is:

$$\frac{\sqrt{(1/n-1)\sum_{i=1}^{n}(c_{ij} - 1/n\sum_{i=1}^{n} c_{ij})^2}}{1/n\sum_{i=1}^{n} c_{ij}}$$

As with the power of dispersion, the measure of the forward linkages differs only in that the row totals, rather than column totals, are used in the computation.

A comprehensive compilation of the measurement of interindustry linkages in developed and developing countries has been set forth by Polenske and Sivitanides (forthcoming); however, for the purpose of the present study, we will consider only the coefficient of variation and power of dispersion.

SHORTCOMINGS OF THE LINKAGE CRITERIA

The attributes and limitations of linkage analysis arise principally from the type of data employed in the calculation. Given that the input-output framework is the primary tool for calculating the different linkage measures, it is reasonable to posit that the limitations of the input-output framework are transmitted to linkage analysis.

In addition to the caveats put forth on the input-output technique, some of the limitations of the technique are put forth by Bulmer-Thomas (1982,p. 195). Because no efficiency criteria, idle capacity, import "linkage" (imports sparked as the result of a new expenditure), government policy, or institutional framework are considered, we can only conduct a partial linkage analysis. In addition, a critical limitation is the static nature of the data collected in the input-output matrix. Given that the data are current-account data, the impact of capital formation is impossible to discern.

We should consider the reflections of Hirschman in 1958 and 1984, as he qualified the expectation of the use of linkage analysis for use in formulating economic development policy. In 1958 (p. 108) he warns:

> The knowledge of the approximate ranking of an industry from the point of view of forward and backward linkage effects as derived from existing developed economies through their input-output tables is, I believe, useful to the economist-planner in underdeveloped areas. It is something to be added to his criteria box. But excessive reliance should obviously not be placed on these rankings, based as they are on a mental experiment subject to numerous qualifications.

and in 1984 (p. 96) he reiterates:

> As with unbalanced growth, there was of course danger that the dynamics that I celebrated could be overdone, to the point of setting up a highly inefficient industrial structure.

In this study we have considered the limitations of linkage analysis and have sought to incorporate additional data in the analysis of the sector in order to assess the impact of changes in the production technology. The excess capacity that was present in 1980 in shrimp processing, for example, would indicate that additional production of shrimp would not trigger the full forward linkage that corresponds to shrimp. Rather, since the idle capacity would absorb the new production, the capital expenditure would take place.

We also should use a variety of specialized sectoral time series to complement the linkage analysis. This permits us to understand the static 1980 data relative to a time series. In this way, we would be able to discern if specific entries in the table are representative of the sector or are an atypical circumstance.

Finally, analysts should consider the institutional, legal, and social factors, presented in Chapter 2 when studying the linkages. In fact, linkages may not be the result of a production strategy or of the technical requirements of the sector, but the influence of social and political factors in the conformation of sectors.

Chapter 5

RESEARCH METHODOLOGY

The objective of this chapter is twofold: to present the nature of the technological change that this study is considering and to put forth a methodology, within the input-output framework, of studying such a technological change. Throughout this study, the analytical framework employed stems from the definition of technology as captured in the intersectoral relationships in an input-output matrix. Within an input-output framework, production technology may be disaggregated into two broad categories: the input mix required for the production of capital infrastructure (capital goods) and the input mix required for the production of goods consumed the same year that they are produced (current expenditures). Thus, basic accounting postulates are used in differentiating between capital and current production technologies. Traditionally, input-output analysts of western thinking have focused their research efforts on production technology of the current expenditures, primarily as a result of the current-account nature of the matrices.

The functional definition of technology that will be used throughout this study is consistent with input-output theory. Technology will be considered as the relative input mix, in value terms, required for the production of the output of a given sector. Leontief (1985, p. 30) explains the difference of the two production technologies ". . . the technical cooking recipe for producing, say, one ton of bread not only has to specify the requisite amounts of current inputs such as flour, milk and yeast, but also has to list needed pots and pans and other kinds of capital goods required for that purpose."

The relative input mix, in value terms, required for the production of output of a given sector is defined by the column normalized vector for each sector of the transaction matrix (Miller and Blair, 1985). The result is the percentage participation of the other sectors of the economy, as well as of imports, in the production of the sector being considered. This input mix, or set of technical coefficients, define the technology of production.

The structural aspect of the input-output technique, stems from the fact that the technical coefficient is similar to a sector-based production function (Miller and Blair, 1985, p. 11).

This study will present technological change in both capital and current accounts. As was presented in Chapter 4, the analytical tool used in this study to quantify the impact of technological change is linkage analysis. In this way, technological change will be considered from a structural perspective as it affects intersectoral relationships in an economic system.

DEFINITION OF STRUCTURAL ANALYSIS

The analysis presented in this study is said to be structural due to the fact that the technical coefficient profile, defines the interaction of the producing sector with "all" other sectors in the system. By treating inputs by their sectoral source and not just as production inputs, analysts using input-output analysis may consider the structure of the economy, that is, the framework of production, as it manifests itself in the production of good or in the delivery of a service.

NATURE OF TECHNOLOGICAL CHANGE

The definition of technology that is applied to input-output systems points the way to the simplest type of technological change. This change is marginal in that although the production framework remains stable, specific inputs in the production process change. In this way, Leontief (1986, p. 34) states: "The technological structure of each sector is represented by a column vector of input coefficients, technological change can be described concisely as a change in the magnitudes of the elements of these vectors."

Typically, technological change, is in response to the availability of inputs, changes in relative prices, or improvements in production techniques. As such, these changes are of a relatively marginal nature. Indeed, although the magnitude of the changes in the specific elements of the input-output matrix may be important, the impact throughout the economy will probably not be dispersed over the entire economic system. The definition presented implicitly defines technological change within the same production framework.

A more radical technological change, one that results in the generation of entirely new production technologies, may not be described by a change in single elements of the input-output matrix but by an entirely new vector. Such radical technological change, suggests an entirely new production technology. The technological change manifested by such a total change may be associated with radical innovation in production technologies. In the case of a sector that depends on a nonrenewable natural resource, technological change may respond to innovations that seek to produce a product derived from the depleting resource. For example, to produce a product derived from the depleting resource. For example, synthetic rubber responds to the relative scarecity of natural rubber. This type of technology is characterized by Carter (1970, p. 171) as a compensatory innovation. As these innovations compensate for the production no longer derived from the natural resource. Through time, it is reasonable to assume that the relative participation of the product produced through the compensatory innovation will increase. In this way, the technical coefficient profile of the sector will be determined by the compensatory innovation.

A more complex alternative arises when considering a renewable natural resource. A renewable natural resource has a limited production capacity, however, this capacity has the characteristic of being sustainable through time. The implementation of a technology to produce the same good will increase the availability of the good in the market. Thus, the definition of the relative contribution of the natural resource and of the technologically produced good will be more complex. Although in some cases the established production is unable to be maintained as a viable alternative, it is conceivable that some technologies will survive in parallel structures. Each technology may be independent of the other but may produce the same good. Aquaculture is such a technology. When native species are cultivated, parallel production "lines" are established. In this way, at least in the short run, the new technology (aquaculture) will be supplementary to the established technology (fisheries).

Thus, this study deals with a supplementary technology and the possible impact that it will have on the structure of the production of shrimp. Although the case study is specific to an activity, it may be representative of other cases where it is desirable to expand the production of a good constrained in production by a renewable natural resource.

NEW TECHNOLOGY OR NEW INDUSTRY?

Compensatory and supplementary innovations lead to an expansion in the production of a good that was already supplied within the economy. Thus, this technological change does not lead to the generation of a new industry per se but to a new production process. The empirical inconvenience of having parallel production processes for a homogeneous product (although in shrimp that is not entirely the case due to aspects discussed in Chapter 2), generates a need to differentiate industries by production process rather than production output. For developing countries, however, the expense, as well as the importance of utilizing the input-output tables to generate a comparative framework across time, limits the changes that may be made to the sector entries of the input-output matrix. However, we could argue that developing economies should be monitored with flexible techniques (instruments), because technological change probably has a greater impact in the structural composition of the economy than in capital-rich economies. In this sense, emerging sectors such as the maquiladora industry and shrimp farming may well merit to be counted as "new industries." Indeed, the impact-analysis technique employed in this study is more related to the genesis of a new industry rather than of marginal improvements in production technologies.

METHODOLOGY

The simulation carried out in this study is similar to the study carried out at the Harvard Economic Research Project and documented by Carter (1970) and by the methodologies suggested by Miller and Blair (1985) in quantifying the impact of a new industry in an economic system.

In the case of Carter (1970), the simulations modeled the advantages of the structure of an economy relative to the structure of a sector being studied. The simulations were executed through the construction of hybrid matrixes. These matrices had imbedded in them the sectoral input and output structure of the sector being studied, while the rest of the matrix reflected the structure of the economy at a different period of time. In this way, Carter sought to test the superiority of an economic structure as this structure changed over time.

According to Carter (1970, p. 168), the construction of these types of hybrid matrices must be carried out with great care.

> Thus it seems important to respect the integrity of observed column structures and not to attempt to alter them piecemeal, except with support of additional technological analysis. In the computations that follow [in her study], the input output structure of the economy will be varied hypothetically by substituting the column structure of one year for that of another but not by varying the individual elements separately.

Miller and Blair (1985) report that there are two ways to develop a framework for the impact analysis of the introduction of a new production activity into an economic area, through the final demand vector and through the addition of new elements into the technical coefficients table of the economy.

Given the objectives of this study, as well as the availability of data, the techniques used in this study are those suggested by Carter (1970). However, we did not conduct an intertemporal analysis of economic structures, rather, we focus just on the substitution of the fisheries vector for vectors that correspond to the shrimp fishery and shrimp aquaculture. Thus, we simulated technological change in the production of shrimp by generating vectors that correspond to the aquaculture and fisheries output of shrimp, in value terms, equivalent to the maximum sustainable yield of the fishery. The vectors were disaggregated into capital expenditures and current expenditures. These vectors were then introduced, replacing the fisheries vector, into the 1980 technical coefficient table of the Mexican economy. From this hybrid transaction table, we conducted the linkage analysis specified in Chapter 4. In this manner, we developed a comparative framework of the economic impact, as quantified by the linkage measures.

The development of production vectors involved the definition of the inputs required in the shrimp fishery and aquaculture shrimp production. These inputs were calculated in June 1980 Mexican pesos. In the case of the aquaculture production, the capital investment was disaggregated into more than 400 components that were classified within the industrial classification framework used to develop the input-output matrix. The same procedure was followed for current-account expenditures. The aquaculture production was disaggregated into 70 inputs and into 19 sectors, while the fisheries was disaggregated into 10 components in 9 sectors.

Fishery Vector

The current-account shrimp fishery vector is imbedded in the fisheries vector of the 1980 Matrix. Given that no comprehensive statistics for the expenditure of the shrimp fleet are available, we calculated the fleet totals from average vessel operation expenditures. The operating costs of the vessels was disaggregated into 10 inputs that were aggregated to 9 sectors of the economy, as shown in Table 1. The high level of aggregation is partially due to the limited number of entries in the input-output matrix; however, detailed data are not readily available. For example, all repairs and maintenance of vessels in the Mexican accounts are entered in one sector. Other economic impact studies of the Gulf of Mexico shrimp fishery (Grant and Griffin, 1979; and Griffen and Jones, 1975) also provide a limited definition of the intersectoral relationships in the shrimp fishery. The traditional breakdown of inputs, such as packing, repair and maintenance, and supplies does not provide enough detail to develop a vector that reflects the fishing activity.

The data required to construct a capital vector for the shrimp fishery, specially in historical costs, are difficult to get. Even legal contracts for the purchase of shrimp fishing vessels only specify the characteristics of the vessel and quote a final price (Roca Construction Company, Brownsville, Texas). Thus, given limited access to published vessel construction cost data, we could not generate a detailed breakdown of the construction components of a shrimp vessel. The shipyards do not keep accurate records of costs, especially when many of the components are outsourced to other manufacturers and the shipyard serves more like an

TABLE 1
ANNUAL OPERATING COSTS OF 1980 MEXICAN INDUSTRIAL
SHRIMP FISHERY FLEET
(1980 Mexican Pesos)

CATEGORY	SECTOR	VESSEL	FLEET
Diesel	33	461409	1285485736
Oil	33	16479	45909407
Food for crew	19	40273	112201778
Engine operation	51-518	48324	134629335
Deck operation	59	48324	134629335
Fresh water	61	6015	16758965
Repair and maintenance	58-580	271823	757298011
Nets	22	90608	252432670
Administration	68-680	20137	56100889
Insurance	66-661	40273	112201778
TOTAL PURCHASES		1043664	2907647904
VALUE ADDED			
Wages	76A	799603	2158928562
Return to capital	76B	1078214	2911178601
Taxes	76C	286387	773244933
TOTAL		3241111	8751000000

Source: Developed by author with data from FONDEPESCA, 1985.

Note: The calculation is based on a 72-foot steel hulled trawler with a 450 H.P. diesel engine. Each vessel makes 7 trips. Each trip lasts 25 days.

assembly center rather than as a manufacturing center. In Table 2 the major inputs required in the construction of a 72-foot trawler are listed. Clearly an important input in the construction of the vessel is steel and steel products. Another important sector is basic chemicals, this due to the paint required for the protection of the hull as well as other parts of the vessel.

Aquaculture Vector

The capital expenditures aquaculture vector was developed in cooperation with the Fideicomiso Fondo Nacional para el Desarrollo Pesquero (FONDEPESCA) (Mexico's national fisheries development trust). Through work conducted at this institution during the last four years, the staff has developed an understanding of the appropriate infrastructure required for the production of shrimp in the Mexican setting. Given that the prices reflect the construction of a 70-hectare (water surface area) farm, economies of scale are already accounted for.

The capital vector was disaggregated into eight major components, as shown in Table 3, and the inputs required in the construction of the infrastructure were then compiled. In total, 400 entries were identified and were grouped into 12 sectors found in the intersectoral quadrant of the input-output matrix, shown in Table 4. The value added component of the capital vector was broken down into labor, returns to capital, and gross taxes.

The current-account production vector was generated through a compilation of technical data from several sources. The primary sources were Manual de Engorda de Camaron a technical manual for the growout of marine shrimp (FONDEPESCA, 1988a) and Marine Shrimp Farming: A Guide to

TABLE 2
MAJOR COMPONENTS OF A SHRIMP TRAWLER

Hull
Cabin
Rigging
Welding
Pimping and pumps
Machinery
Wich
Steering system
Electrical system
Painting and sandblasting
Safety and fire equipment
Outfitting
Electronics
Refrigeration
Fuel and oil tanks

Source: Roca Construction Company, 1990

TABLE 3
BREAKDOWN OF CATEGORIES IN THE CONSTRUCTION OF A SHRIMP FARM IN MEXICO

Preliminary works
Earth movements (levees)
Water intake into farms and into ponds
Water outflow into farm and into ponds
Macro biological filter
Pumping station
Pumping equipment
Electrification

Source: FONDEPESCA, 1990

TABLE 4
SUMMARY OF INPUT REQUIREMENTS FOR THE CONSTRUCTION OF A 70 HECTARE SHRIMP FARM AND 1285 FARMS (TOTAL SURFACE AREA OF 90,000 HECTARES)

CATEGORY	SECTOR	INVESTMENT PER FARM (1980 PESOS)	TECHNICAL COEFFICIENT	INVESTMENT 90,000 HA. (1980 PESOS)
INTERMEDIATE PURCHASES				
Cement	44	331415	0.0387	426105591
Bricks	45-451	5835	0.0007	7501578
Cement machinery	51	9060	0.0011	11648754
Prefabricated concrete	44	248981	0.0291	320118337
Asbastos Board	45-453	19936	0.0023	25631721
Diesel	33	143573	0.0168	184593980
Electrical infrastructure	52-521	366249	0.0428	470891571
Equipment and machinery	51-511	381611	0.0445	490642552
Gravel	09-092	51581	0.0060	66318926
Topography equipment	51-511	231	0.0000	297023
Lime	45-452	1145	0.0001	1472567
Paints	40-401	5653	0.0007	7267793
Plastics	42-421	67	0.0000	85577
Rubber (tires)	41-410	6563	0.0008	8438468
Pump	51-515	1070702	0.1250	1376616857
Sand	09-092	35759	0.0042	45975735
Sodering	49-490	2867	0.0003	3685667
Nails	50-502	4656	0.0005	5986555
Wire	50-507	13920	0.0016	17897556
Steel rods	50-504	404581	0.0472	520175269
Steel pipes	46-452	11048	0.0013	14204252
Other steel products	50-504	165453	0.0193	212725191
Heavy equipment	60	855938	0.0999	1100491507
Pickup trucks	56	239056	0.0279	307357251
Water	61	1120	0.0001	1440353
Wood products	29-209	85441	0.0100	109852970
TOTAL INTERSECTORAL PURCHASES		4462441		5737423604
VALUE ADDED				
WAGES	76-A	1424971	0.1663	1832105588
PROFITS	76-B	1561854	0.1823	2008097688
GROSS TAX	76-C	1117390	0.1304	1436644032
TOTAL		8566655	1.0000	11014270912

Source: Developed by author from data in FONDEPESCA, 1990.

Note: The calculations are based on the construction of earthern ponds with pumping facilites. The costs were developed from actual engineering specifications of farms that have been constructed in Sinaloa, Mexico.

Feasibility Study Preparation (International Finance Corporation, 1987). The operating inputs for the semi-intensive growout of marine shrimp are concentrated into four major categories: labor, energy and balanced feed, fertilizer and chemicals, and transportation. Thus, the disaggregation of the inputs is simplified in comparison with the capital vector. The only input that has a complex composition is the balanced feed. In order to capture the intersectoral linkages in the production of the balanced feed, we disaggregated the inputs of the feed and allocated them to the respective cells of the animal feed vector. Only an estimated processing cost was allocated to the balanced-feed entry in the input-output table. The transaction and technical coefficient vector of the operation of the aquaculture production is presented in Table 5. The current-account vector corresponds to 11 sectors of the economy as well as 9 sectors in the production of the balanced feed.

IMPACT SIMULATION

The first task in the impact simulation process was to enter the 1980 input-output of Mexico into a software program that would facilitate its manipulation. Therefore, the 93x93 sector/commodity 1980 input-output matrix for Mexico was entered into the ECONIO 4.0 input-output software program (Resource Economics and Management Analysis, Inc., 1989). From this transaction table, an input technical coefficient "A" matrix (column normalized) as well as an output coefficient "B" matrix (row normalized) table were generated. Furthermore, the I-A matrix (C matrix) and the I-B matrix (D matrix) were derived. The A and C matrices that were derived from the transaction table were identical to those reported by the INEGI,

TABLE 5
ANNUAL OPERATING COSTS OF A 70 HECTARE SHRIMP FARM AND
90,000 HECTARES OF SHRIMP FARMS IN MEXICO
(1980 Mexican Pesos)

CATEGORY	SECTOR	70 HECTARE FARM	TECHNICAL (1) COEFFICIENT	90,000 FARM HECTARES
FEED:				
Fish meal	4	221286	0.27721	284511150
Minerals	10	25290	0.03168	32515560
Soybean meal	1G	107482	0.13464	138191130
Corn starch	1A	56902	0.07128	73160010
Oil	17	18967	0.02376	24386670
Vitamins	35	25290	0.03168	32515560
Paper	31	9484	0.01188	12193335
Transport	64	9484	0.01188	12193335
Medications	35	6322	0.00792	8128890
Wages	76A	44257	0.05544	56902230
Production	76B	151739	0.19009	195093360
Net tax	76C	-44257	-0.05544	-56902230
	77			
TOTAL VALUE ADDED		151739		333284490
TOTAL PURCHASES		480508		617795640
OTHER INPUTS:				
Diesel (pump)	33	159678	0.20003	205300000
Gasoline	33	53	0.00007	68369
Rubber (TIRES)	41	2	0.00000	2607
Oil	33	2	0.00000	2044
Car parts	57	44	0.00005	56079
Diesel	33	14	0.00002	17520
Rubber tires	41	5	0.00001	5840
Maintenance	57	45	0.00006	58400
Phosphate	36	14	0.00002	18509
Amonia	36	7	0.00001	8638
WAGES	76A	4100	0.00514	5271000
RETURN TO CAPITAL	76B	1876	0.00235	2411804
TAXES	76C	182	0.00023	233571
TOTAL VALUE ADDED		6157		7916375
TOTAL PURCHASES		159863		205538006
TOTAL		798267	1.0000	1164534511

Source: Developed by author with data from FONDEPESCA, 1990.

(1) The technical coefficient was calculated from total purchases
Note: The inputs have been calculated to model a production of 510 Kg./hectare/year. The production technique is semi-intensive rearing in earth ponds.

while the B and D matrices were not compared, given that these tables were not published.

The objective of the impact simulation was partly to define the absolute impact that shrimp fishing and shrimp husbandry have on the Mexican economy; however, most importantly, we sought to capture the relative contribution of both technologies. Thus, the more interesting aspect of the impact simulation is generating the differences between the two technologies.

The economic impact analysis was carried out in the following four stages:

1. The impact of the fisheries sector on the Mexican economy.

2. The impact of the current-account expenditures of the shrimp fishery.

3. The impact of the current-account expenditures of shrimp cultivation.

4. The impact of the capital-account expenditure of shrimp cultivation.

The participation of the fisheries sector, from a current account perspective, in the Mexican economy is defined by the input and output vectors in the transaction table. We used linkage analysis to develop a characterization of the sector in the context of the Mexican economy.

CONCLUSION

In this chapter, we have presented a viable methodology to simulate technological change from a general equilibrium perspective. The approach that we adopted follows the methodology established by Carter at the Harvard Economic Research Project. This methodology is used to simulate technological change and linkage analysis serves to assess the impact that technological change has on the system. We believe that this general equilibrium approach satisfies the research objectives established in Chapter 1.

Chapter 6

ANALYSIS OF THE SHRIMP FISHERY AND SHRIMP AQUACULTURE

The objective of this chapter is to present a detailed analysis of the development of shrimp fishery as well as a parallel aquaculture production. We conduct the study using specialized data as well as data generated from the input-output table, with emphasis on value added, an aspect that is not considered when the analysis is carried out from just an intersectoral perspective.

Consistent with the structural approach of the study, we will present the sector relative to other sectors in the economy. This will be accomplished by indicating the rank of the sector according to different criteria. Given that the fishery sector depends on a natural resource as its production base, we will contrast it with other sectors of the economy that rely on natural resources as their primary inputs. These primary sectors, comprised of agriculture, animal husbandry, and forestry are disaggregated into 24 sectors in addition to the fisheries sector as shown in Table 6.

ROLE OF THE FISHERIES SECTOR IN THE MEXICAN ECONOMY

In 1980, the fisheries sector in Mexico contributed 3.6% of the total output of the primary biological sectors. This placed the sector 7th among the 25 biological sectors in terms of gross value of production. In terms of employment, the fisheries sector accounted for 196,000 employees out of the 5,500,000 employees in the primary sectors, or 3.6% of the primary sector employment.

TABLE 6

DISAGGREGATION OF PRIMARY SECTORS OF THE MEXICAN ECONOMY--1980 INPUT-OUTPUT MATRIX

CORN
RICE
WHEAT
BEANS
SORGHUM
BARLEY
SOY BEANS
SAFFLOWER
SESAME
COTTON
SUGAR CANE
COFFEE
TOBACCO
COCOA
SISAL
OTHER AGRICULTURAL PRODUCTS
CATTLE
PORK
SHEEP AND GOATS
POULTRY
BEEKEEPING
OTHER LIVESTOCK
FORESTY--WOOD PRODUCTION
FORESTRY--NONWOOD PRODUCTS
FISHERIES AND GAME (1)

Source: Matriz Insumo Producto de Mexico, Desagregacion del Sector Agropecuario y Forestal, INEGI, 1987

(1) The game component of the fisheries sector is less than 0.05%

Relative to the other primary sectors, and in terms of the gross value of production, the fisheries sector depended heavily on intermediate inputs, which comprised approximately 31% of the value of production. This may serve as an indicator of the level of dependency of the fisheries sector with the rest of the economic system. In this regard, the fisheries sector was 6th out of the 25 primary sectors, and 59th out of 93 in terms of the whole economy. From the data in the transaction input-output matrix, the sector appears to be almost entirely independent of imports (0.02%), as it is 87th out of 93 in the consumption of imported goods and services; however, according to staff of the FONDEPESCA, the import component of the sector is much higher. An exemplary case of this is found in artisinal fisheries, where imported outboard engines comprise over 50% of capital costs. In the shrimp fishery, the engines, hydraulic equipment, electronic equipment and some of the paints are all imported into Mexico (FONDEPESCA, 1990 Personal communication).

ANALYSIS OF VALUE ADDED

The decomposition of the value added into wages and salaries, returns to capital, and net indirect taxes and subsidies is important in understanding the structure of the sector. Wages and salaries as a percentage of gross value added (17.3%) in the fisheries sector represented the median in the whole 1980 economy, ranking 45 out 93 sectors. In the case of the shrimp fishery, wages and salaries are distributed among the crew of the vessel as a share (21.0%) of the value of the landings (FONDEPESCA, 1985). The sector has a relatively high rank in return to capital. With a 50.4% returns to capital, the sector ranks 21 out of 93 from a national perspective and 13 out of 25 among the primary sectors.

As presented in Chapter 3, the distribution of the components of value added from 1970 to 1985 reveals a dramatic trend. Wages and salaries decreased during this ten-year period in direct inverse relationship with the gains made by the returns to capital. In addition to the institutional factors that are associated with the decreasing productivity of vessels, other factors, such as increasing production costs of an inefficient energy-intensive fleet (wood hulls), may also explain part of the shift in returns to capital and wages. These factors are clearly applicable, during the period being considered, to the Gulf of Mexico fishery. The Gulf fishery reached its maximum sustainable yield of 14,489 tons in 1970. However, from 1970 to 1980, the fishery became overcapitalized by the addition of 453 vessels beyond those necessary for the extraction of the maximum sustainable yield. This large overcapitalization of the Gulf fishery--in terms of vessels--brought about a turn around in the distribution between wages and capital. Because wages are related to the output of the sector, and this output is fixed at a maximum level, the costs associated with production "dilute" the constant wage. In addition, because the sector is organized as cooperatives, the average wage of the fishers was reduced by the proportion of new fishers entering the fishery. The same analysis is applicable to the Pacific fishery; however, because the maximum sustainable yield of 29,076 tons was not reached until 1982, the Pacific fishery was managed with more prudent expansion policies.

The last component of value added to be considered is the taxes generated by the sector. In 1980, only 48% of the primary sectors had positive net tax payments to government. The fisheries sector was third out of the 12 primary sectors that contributed more to the government than it received in subsidies (0.6% of its net value of production). From a national perspective, the sector ranked 51 out of 93 sectors in terms of net taxes paid to the government as a percentage of net value of production.

ECONOMIC IMPACT OF SHRIMP FISHERY ON MEXICAN ECONOMY

From a structural perspective, the economic impact of the shrimp fishery may be divided into inputs and into outputs. In this way, the analysis will correspond to the backward and forward linkages of the sector with the rest of the economy.

Inputs

In terms of inputs, the principal economic impact of the Mexican shrimp fishery on the Mexican economy was the operation cost of the fleet. In 1980, 2,786 vessels operated. The fixed operating costs of the fleet, 4,361 million pesos, represented 24.4% of the total input cost of the 1980 fisheries sector (calculated from data in FONDEPESCA, 1985). The activities related to processing, packaging, and marketing accounted for 10.7% of the fisheries inputs (1,917 million pesos). Thus, inputs of the shrimp fishery accounted for 43.6% of the total value of inputs for the sector.

In terms of employment in the shrimp fishery, the Secretaria de Pesca reported that in 1980 there were 49,000 registered (cooperative) shrimp fishers, or approximately 25% of the total employment in the sector. However, the 2736 vessels can only accommodate approximately 17,000 fishers. Thus, only 34.6% of those licenced to fish shrimp participated in the industrial fishery. No data were available regarding the artisinal shrimp fishery; however, it is unlikely that it could accommodate the remaining 32,000 fishers that have shrimp fishing rights. The implications of having only 34.6% of licenced shrimp fishers employed in the shrimp fishery is critical. Not only is the fishery overcapitalized in terms of infrastructure but also in terms of labor. The extension of fishing rights to a number of persons that exceeds the productivity of the resource is a reflection of the political--rather than technical--management of the fishery.

Outputs

The economic impact, in terms of outputs, may be disaggregated into the national and export market. The distinction of the markets is important in order to account for the source of demand as well as to determine the magnitude of the revenues derived form the sale of the product. As a freely traded good, the domestic price of shrimp corresponds to the international price. However, given the characteristics of the product that is exported in terms of the size and quality of the shrimp, the average export price in 1980 was 25% higher than shrimp sold in the domestic market (FONDEPESCA, 1985). Although the relative participation of foreign versus the domestic market is defined by factors such as the international price of shrimp, characteristics of the production, domestic development policy, foreign exchange rate, and disposable income of nationals, the internal instability in the determinants of domestic demand renders the export market as an attractive dependable market. Furthermore, shrimp aquaculture in the context of national economic policy is seen exclusively as an industry that will bring foreign exchange into the country.

In 1980, 86.3% of the total landings were exported, and the remaining 13.7% were destined for local consumption. The distribution between local consumption and export of shrimp, during the ten-year period between 1973 and 1983 had important fluctuations, as shown in Table 7. It is important to note that 1980 was the year with the greatest percentage of exported production, the percentage being significantly higher than in any other year. This export-oriented production will generate a forward linkage profile inconsistent with the average of the previous years. Thus, although we are using 1980 as the year of the study, it may not be a representative year, at least from the output point of view. Export production had a value of 8,751 million pesos in purchaser prices (7,263 million pesos producer price) or 387.8 million 1980 dollars and production costs of 6,694 million pesos (296.6 million 1980 dollars), which corresponds to 37.4 % of gross value of production and 40.6 % of the gross value of sales of the entire sector. The primary buyer of Mexican shrimp is the United States. In 1980, 93.3% of the export sales destined to the United States, 3.8% to Japan, and 2.9% to other countries (Secretaria de Pesca, 1986)

Capital Stock

The capital stock of the shrimp fishery considered in this study focuses on the vessels. The shrimp fleet in 1980 was composed of 2786 vessels of similar dimensions; however, the age composition, as well as the

TABLE 7
DISTRIBUTION OF DOMESTIC SHRIMP CONSUMPTION AND EXPORT
OF LANDINGS IN MEXICO: 1973-1983 (IN TONS)

YEAR	TOTAL LANDINGS	EXPORTS	%	DOMESTIC	%
1973	46076	31137	68%	14939	32%
1974	47705	28498	60%	19207	40%
1975	43786	33821	77%	9965	23%
1976	47244	30569	65%	16675	35%
1977	46274	30299	65%	15975	35%
1978	43750	32175	74%	11575	26%
1979	47955	33058	69%	14897	31%
1980	50490	43606	86%	6884	14%
1981	49184	33093	67%	16091	33%
1982	53127	32928	62%	20199	38%
1983	54432	32320	59%	22112	41%

Source: FONDEPESCA, 1985.

material of hull construction make any present value estimates of the fleet difficult. The approach we have taken in this study is to calculate the replacement cost of vessels that corresponds to 1980 technology. This assumption of a homogenous fleet is valid given the current trends in the replacement of older wooden-hulled vessels.

A critical determinant in the simulation of the formation of capital in the fisheries sector is the determination of the number of vessels to incorporate into the analysis. It is clear that the number of vessels in the fleet, particularly in the Gulf of Mexico, exceeds an economically efficient number.[10] In addition, the efficiency criteria must be placed in a complex environment of dynamic prices and unstable interest rates. Both factors affect the economic feasibility of the vessels by increasing or decreasing the landings required for payment of fixed costs. Since 1970, both factors have contributed to increasing the minimum catch required to meet fixed cost expenditures.

In 1980, the 2,786 vessels had average landings of 15.0 tons per year (heads on weight).[11] However, with the prevailing cost of capital (15%), the minimum annual landings necessary to meet operating costs was estimated be 27.3 tons. The importance of targeting the expected production per vessel is based on the limited production of the fishery. If a lower per vessel production is acceptable, then more vessels will be

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[10]In this instance, efficiency refers to a vessel that can generate enough revenue to cover its fixed and variable operating expenses

[11]It is important to note that average landings may not be the best measure of ship performance. For example, in most open access industrial fisheries, 10% to 15% of the fleet is responsible for 80 to 85% of the landings (Sprague, 1990).

required to extract the resource; thus, the capital stock of the sector will be greater. In the present study, we choose to maintain the fleet at the same level; however, it is interesting to note that the impact of using an efficiency criteria, reduces the fleet from 2696 to 1494 vessels. At least two important factors must be considered in the use of an efficiency criteria for the determination of the fleet: the savings of the capital required for the construction of the vessels and the resources saved from operating costs foregone. From an equity point of view, we can identify all the benefits foregone from the capital expenditures. In addition, the "excess" fleet provides direct employment to 7,212 fishers.

In attempting to calculate the effect of the overcapitalized extraction infrastructure, two basic factors must be considered: (i) the forward and backward linkages of the shrimp fishery and (ii) the temporal distribution of the linkages. For example, capital formation linkages may have very well-defined impacts on specific sectors of the economy. In addition, the secondary and tertiary effects of the expenditure, as it refers to the backward linkages, may be defined in a narrow period of time. However, the recurring nature of the operating expenditures, partially captured in the backward and in all of the forward linkages, must be defined in the context of the life of the infrastructure. As such, in order to calculate the impact of the "excess" capacity, it would be necessary to include a measure of the present value of the expenditures for a period of 20 years, a period that corresponds to the life of the vessel.

ECONOMIC IMPACT OF SHRIMP CULTIVATION

The economic impact of the growth of shrimp aquaculture in Mexico will be dependent on the level of development, that is, the number of hectares of coastal mudflats that will be transformed into farms. As stated in Chapter 1, in this study we seek to determine the economic impact of the production of an equivalent output as the shrimp fishery. In order to simplify the analysis, we have assumed that the average price of shrimp produced in farms and on the fishery is equal.

In this sense, a critical technical parameter is the productivity of each acre farmed. We have selected a conservative estimate that reflects the experience of the 100,000 hectares farmed in Ecuador. The yield used in the analysis is 510 kilograms per hectare-year (Fondepesca 1988a). Associated with this output the most critical recurrent costs are the energy required for the water exchanges and the balanced feed for the animals. The capital expenditures required to develop the 90,000 hectares necessary to produce an output equivalent of the fishery centered on pond construction, construction of water access, and the purchase and installation of pumps.

Inputs

The current-account impact of a massive expansion of shrimp aquaculture is reflected by the production vector as shown earlier in Table 3. As with other species produced in industrialized aquaculture, feed costs are the highest recurring cost. An important consideration in the feed costs is that two critical ingredients in the balanced feed, maize and soybeans, must be imported to meet the domestic demands. In addition, the balanced-feed sector relies on 49% of its inputs as imports. Finally, there was a net government transfer equivalent to 7.4% of the sector's output. Thus, an increased demand on a sector that relies on imports as well as on subsidies does not appear to be a favorable strategy.

The last input to be considered is labor. Under the semi-intensive cultivation practice, each hectare will produce 0.2 full-time jobs. Thus, the 90,000 hectares will produce approximately 25,000 full-time jobs. If the employees are paid wages that comply with prevailing labor laws, the wage bill for the employees is 5,000 million pesos.

Value Added

It is difficult to forecast the value added structure of a new industry; however, it is reasonable to make some observations. As indicated earlier, the wage bill for the aquaculture production will be larger than that of the fishery. As such, the returns to capital are expected to be smaller. In the computation of the wage, we calculated the real wage to workers. It is fairly feasible that a lower rural wage (which breaks the minimum wage laws of the country) may prevail in the area. Another point to consider is that through automation and experience, it is feasible to reduce the employment requirements. Thus, the wage bill could be overestimated. In regards to the tax payments, we imputed a value added tax of 15% on the inputs used in the production of cultivated shrimp.

CONCLUSION

The Mexican shrimp fishery is vastly overcapitalized as well as flooded with licenced fishers. The overcapitalization of the fishery is reflected in the technology of production, where the inputs required for the production of the maximum sustainable yield are overestimated. As such, the structural composition of the fishery reflects policy initiatives rather than technicoeconomic criteria. The growth of the shrimp aquaculture sector in Mexico would take place under a private sector policy environment. Thus, it would participate in the Mexican economy under an efficiency criteria rather than policy-directed growth.

From this chapter, we propose that a critical difference between the two production technologies is the structure of value added. The definition of the structure of value added of the shrimp aquaculture--which is the result of development policy as well as the institutional arrangements between capital and labor and capital and government--provides a unique opportunity to structure a sector with long-term sustainable growth. We believe that it is essential to learn from the mistakes made during the development of the shrimp fishery. As one of the most important rural industrialization projects to be undertaken in Mexico during this decade, the development, planning, and implementation of a shrimp aquaculture industry will incorporate political considerations. However, if the political directives result in overcapitalization, shrimp aquaculture will not generate the expected benefits.

CHAPTER 7

LINKAGE ANALYSIS

> Although there are limited opportunities to permit persons to fulfill their potential, many believe that it is a lack of preparation that keeps the people away from the fruits of success, it is time to consider that the system itself may generate an insufficient amount of opportunities.
>
> David Barkin, 1971. p. 234

The linkage measures developed in Chapter 3 form the framework for the analysis of selected results. Although the analysis was carried out for the Mexican economic system, we refer to other sectors in order to put the fisheries sector in perspective. We begin by presenting the fisheries sector from a linkage perspective, providing both absolute results and relative participation, expressed as rank in the measures being considered. Given the nature of the fisheries sector as one that depends on a biological resource, we have chosen to present the analysis of the sector relative to the economic system as well as relative to other primary biological resources. Indeed, 25 out of the 93 sectors in the input-output table are primary biological sectors.

In the second part of the chapter, we present the results of the simulations of technological change. The simulations, based on the vectors constructed and presented in Chapter 5, represent a general equilibrium analysis of technological change. The methodology used to generate the simulations in a general equilibrium framework was presented in Chapter 4.

Although the analysis of the sector in the first part of the chapter includes information of the forward linkage, the analysis of the simulations will focus only on the backward linkages, which are the most significant linkages in terms of size. Furthermore, insufficient data were available to analyze the forward linkages.

THE FISHERIES SECTOR

The fishery sector can be characterized by its relatively important backward linkages, as shown in Table 8. Both the direct (0.251) and the total backward linkage (1.486) rank 5 out of the 25 primary sectors and 68 and 53, respectively, out of 93 from a national perspective. In contrast, the direct forward linkage (0.104) and the total forward linkage (1.455) rank 12 and 20, respectively, out of the 25 primary sectors. Nationally, the direct and total forward linkage rank 63 and 59, respectively out of 93 sectors.

The importance of the backward linkage is consistent with the high input component (31.6%) of the sector described in the preceding chapter. In terms of the measure of the dispersion of the linkages of the fishery sector relative to other sectors in the economy, the measures are identical to those of the total backward linkage. The sector ranks 5th out of 25 in the primary sectors, while 53th out of 93 among all the sectors in the economy. Although the relative importance of the sector as a primary sectors is evident by its rank, its value of 0.970, (less than unity) indicates that investments in the fishery sector yield below average backward linkages relative to the other sectors in the economy. The sensitivity of dispersion for the forward linkage yields almost identical results as the total forward linkage. However, as in the case of the power of dispersion, the value of the sensitivity of dispersion, which is below unity (.801), indicates that investment in the sector yields below average forward linkages compared with other sectors.

In the case of the coefficient of variation for the backward linkage, which measures the extent to which the sector draws evenly from the other sectors in the economy, the fisheries sector has a very high relative rank. In terms of the economy as a whole, it ranks 40 out of 93, and it is the fourth among the 25 primary sectors. In contrast, the coefficient of variation for the forward linkages places the fishery sector as one that has an uneven participation by other sectors. This is understandable given the homogeneous and specialized nature of the production. In addition, the nature of the type of imports into the United States, regulated by the domestic shrimp lobby--as unprocessed "primary" product--which reserves the high value added products (such as breaded shrimp) to U.S. fishers, limits the forward linkage of the sector.

LINKAGE ANALYSIS AND TECHNOLOGICAL CHANGE

The analysis of technological change will be presented in relative terms to the fishery sector and its linkage measures presented in Table 8. We separated the investment vector into capital costs, equipment, and production inputs. We then classified these inputs into three categories in order to group inputs that have similar life. Thus, if a farm has a useful life of 15 years while that of equipment is five, and recurrent costs are annual, then the stream of linkages that will be generated over the life of the farm can be computed. However, given the lack of wage and salary and other value added information for equipment, we could not

TABLE 8. SUMMARY OF LINKAGE MEASURES OF THE MEXICAN FISHERY SECTOR: 1980

MEASURE	BASELINE	A	B	C	D	E
TOTAL BACKWARD LINKAGE	1.48606	1.41294	1.66039	1.90592	1.251470	1.73401
DIRECT BACKWARD LINKAGE	0.3164	0.2643	0.4272	0.5836	0.1494	0.4262
POWER OF DISPERSION	0.9701	0.9227	1.0824	1.2413	0.8183	1.1297
COEFICIENT OF VARIATION	6.5117	6.8349	5.8327	5.1794	7.7377	5.6680

Source: Calculated by Author from Matriz de Insumo Producto de Mexico. Desagregacion del Sector Agropecuario y Forestal. INEGI, 1988.

Simulations:
A.- OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITH THE FISHERIES SECTOR PRODUCING NORMAL OUTPUT.
B.- CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITH FISHERY SECTOR OPERATING NORMALLY.
C.- CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER ACTIVITY IN THE FISHERIES SECTOR.
D.- OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER OUTPUT FROM THE FISHERIES SECTOR.
E.- OPERATION OF SHRIMP FLEET WITHOUT ANY OTHER PRODUCTION FROM FISHERIES SECTOR.

generate detailed linkage analysis for this component. Nevertheless, we calculated the consumer price of the equipment as seen in Table 9.

Formation of Capital Infrastructure for Shrimp Aquaculture

The investment required for the construction of the 90,000 hectares of shrimp farm is 11,014.27 million pesos ($ 487.4 million 1980 U.S. dollars). Whereas the total output of the sector was 17,400 million pesos. This expenditure is distributed among 21 sectors. The simulation of the construction of the infrastructure was conducted under two conditions. The first was the construction of the farms in a "fisheries" sector whose only inputs were those necessary for the construction of the aquaculture infrastructure. For the second simulation, we considered the fisheries sector as it stood in 1980 and added to it the construction of the infrastructure.

Under the first alternative, the direct backward linkage of the sector increases from 0.316 to 0.427 or 35%, while under the second alternative, the backward linkage of the sector increased from its baseline from 0.316 to 0.583, or an increase of 84.4%. The fact that the direct backward linkage is smaller when considered in the context of the sector operating under normal purchases of inputs may be due to the high value added component of the sector that draws away from intersectoral relationships. Thus, since the construction activity has direct backward linkages above that of the operating sector, the resulting "hybrid" linkage will be in between the two values. This is specially true when we consider that the total investment of the infrastructure is a fraction of inputs of the sector in 1980.

TABLE 9
INVESTMENT IN EQUIPMENT REQUIRED FOR THE OPERATION OF A 70 HECTARE SHRIMP FARM AND 90,000 HECTARES OF SHRIMP FARMS
(1980 Mexican Pesos)

CONCEPT	SECTOR	INVESTMENT PER FARM	INVESTMENT PER 90,000 HECTARES
Automobile	56	881400	793260000
Motorcycles	56	135600	122040000
Steel	7	19210	17289000
Services	68	22.6	20340
Sand	9	678	610200
Plastics	42	11096.6	9986940
Glass	43	113	101700
Fiber glass	37	18080	16272000
Tractors	51	452000	406800000
Equipment	51	24521	22068900
Electronic equip.	55	15029	13526100
Synthetic fiber	37	2486	2237400
TOTAL		1560236.	1404212580

Source: Calculated from FONDEPESCA, 1990.

The total backward linkage of the construction of the infrastructure yields the seventh highest total backward linkage in the economy. The linkage increases from 1.515 to 1.997 or 31.8%. When the construction is considered in the context of sector, the backward linkage increases only 13.2% from the baseline to 1.715. The same rationale as with the direct linkage may explain the smaller increase in the linkage.

The insight that may be derived through general equilibrium analysis is evident in the stimulus that is registered as changes in sectors where no direct investment was made. A crude measure of the impact that the capital expenditure has upon other sectors is the number of sectors whose total backward linkage increased as a result of the expenditure. In this sense, the construction of infrastructure in a fictional "passive" fisheries sector stimulates indirectly 13 sectors. However, under the normally operating fisheries sector, the construction expenditure stimulates increases in the total backward linkage of 50 sectors. A more refined measure of this change is registered in the power of dispersion.

The power of dispersion measures the strength of the linkage relative to the average linkage in the economy. Because in this measure unity represents an average linkage, any movements toward unity and beyond it, represent an increase in the relative strength of the linkage. It is interesting to note that the construction of the infrastructure generates an almost uniform decrease in the power of dispersion under both the isolated construction as well as in the construction under an operating sector. However, as expected, the power of dispersion for the fisheries sector increases under both construction alternatives. In the case of the isolated construction, the power of dispersion increases from 0.970 to 1.241, and under the operating sector, it goes up only to 1.084. The fact that the power of dispersion goes up less when calculated as a part of the operating sector simply means that the relative weight the fishery linkages (of below the economy-wide average linkage) reduces the linkage effect of the expenditure.

Operation of Shrimp Farms

The annual operating costs of the shrimp farm are represented by the vectors in Table 3. The simulations of the operation of the 90,000 hectares were conducted under two different alternatives. For the first, we simulated the impact of the operation of the aquaculture facilities complementing the activities of the fisheries sector. In the second simulation, we measured the linkage impact of shrimp aquaculture in isolation, thus the fisheries production vector was replaced with the shrimp aquaculture vector.

The impact, in terms of the direct backward linkage, of the aquaculture production when considered as a supplement to the fishery sector was a decrease in the direct backward linkage from 0.316 to 0.264, a drop of 14.3%. When the aquaculture production is considered without the production of the fisheries sector, the direct backward linkage is even smaller, dropping from 0.316 to 0.167, or 52.8%. The logic behind this drop in the direct backward linkage is the increased proportion of value added in shrimp production as compared with traditional fisheries. A similar pattern is followed for the total backward linkage. The total backward linkage for the aquaculture production of shrimp is lower than the total backward linkage for the entire sector. In the case of isolated aquaculture production, the total backward linkage is 1.25, while as part of the fisheries inputs it is 1.41, this represents a decrease of 23.4% and 7.3%, respectively, from the baseline. The smaller total backward linkage of the aquaculture production is due to the importance of the value added rather than intermediate purchases in the production of farm-raised shrimp. This implies that the household and owners of capital will have a greater participation in the aquaculture based production than in the fishery based production.

The dispersion of the "aquaculture production induced linkages" under both alternatives indicates that the aquaculture investment stimulates other sectors in a more uneven manner than the fishery sector. However, shrimp aquaculture induced linkages, as measured by the power of dispersion, are stronger that those of the fishery sector.

Aquaculture Production and the Fishery

Given the nature of national and sectoral accounts, we should consider what linkage impact will the shrimp aquaculture have on the fishery sector and on the national economy; however, a more interesting question is how do aquaculture-induced linkages compare to the linkages generated by the fishery.

The estimated direct backward linkage of the current expenditures of the Mexican shrimp fleet in 1980 was 0.426, while the estimated linkage for the shrimp-farming industry was 0.149. The primary factor that determines the backward linkage is the relative distribution of the value added to the intersectoral relationships. Thus, since the aquaculture sector has a greater proportion of its value of production as value added than the fishery sector, the direct backward linkage of the aquaculture production is considerably smaller.

The total backward linkage of the current expenditures of the shrimp fleet is much greater than the current expenditures of the aquaculture sector. Indeed, if the total backward linkage for the sector is considered as a weighted average for the individual fisheries, then it is evident that the shrimp fleet has an above average backward linkage within the sector.

The strength of the aquaculture and fishery production linkages, as measured by the power of dispersion, reveal that although the fisheries sector has a below economy-wide total backward linkage, the operation of the fleet has an above average linkage. In the case of aquaculture, the power of dispersion is below unity; thus, the backward linkages is less than the average linkage in the economy.

The dispersion of the linkages throughout the economy are more evenly spread with the fisheries production than with aquaculture production. This finding is fairly significant because the inputs for the fleet covered only six sectors compared with the 20 sectors that sell inputs to the aquaculture production of shrimp. Thus, it is possible that the fleet draws from sectors that, in turn, draw evenly from the other sectors of the economy.

Key Sectors in Aquaculture Development

Our objective in this study centered on developing an understanding of the impact that shrimp aquaculture development would have on the Mexican economic system. By differentiating the linkages developed by the activity into capital and recurrent costs, we are able to estimate the short-term "one-time" linkages as well as the linkages that will be maintained as long as the infrastructure operates. Thus, from a planning perspective, it is interesting to consider what sectors will be directly and indirectly affected by the construction and by the operation of the farms.

The capital expenditure required for the construction of 90,000 hectares of shrimp farms in 1980 would have been valued at 487.4 million U.S. dollars.[12] The construction of the infrastructure involved direct purchases by the fisheries sector from 20 sectors in the economy. As a result of the expenditure, 50 sectors had increases in their total backward linkage.

Some of the linkages that are generated by the capital and recurrent expenditures may not hold importance from a planning perspective--perhaps due to the relatively small contribution of the aquaculture sales to the total sales of the sector. However, from the data generated and the framework presented, further research could be developed to determine the critical sectors for aquaculture development. For example, the growth of shrimp aquaculture would draw from sectors that are heavily subsidized. If production strategies are formulated in ways that make them vulnerable to changes in the level of participation of the government, then the developmennt will be vulnerable to general policy changes.

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[12]Even though relative prices have changed in the economy and the real wage has fallen by more than 40% since 1980, it is interesting to note that the same infrastructure constructed in 1990 would have cost 477.9 million dollars.

IMPACT ANALYSIS: A GENERAL EQUILIBRIUM APPROACH

The input-output technique that we utilized in this study permits us to define the impact that the capital and current account expenditure has on the Mexican economy. Although the expenditure is small relative to the gross national product of the country, the effect is registered throughout the economic system. We present the results of technological change in aggregate measures, with the expectation that the data provided can serve in the design of more detailed regional impact studies.

In order to capture the tendency of the impact of technological change, we have selected to generate aggregate statistics that reflect a cumulative impact. In this way, we generated the net change in the total backward linkage, coefficient of variation of backward linkages, and power of dispersion for each simulation as a single statistic for the entire economy.

The operating expenditure of the Mexican shrimp fishery increases the backward linkages of 74 sectors, while it decreases the backward linkages of 10 sectors, as shown in Table 10. In contrast, the operating expenditure of shrimp farms would increase the backward linkage of 57 sectors while decreasing it in 26 sectors. The net effect is a contribution to the total backward linkage of the economy by the shrimp fishery of 0.28 and a decrease of 0.24 by the shrimp aquaculture[13] Thus, from a general equilibrium perspective, the operation of the shrimp fleet

[13]This was calculated by adding all the increases in the backward linkage, relative to the baseline economy, and subtracting from it the summation of the reductions in the total backward linkage. The result is the net change in backward linkage generated as a result of the different simulations.

TABLE 10. SUMMARY OF TOTAL BACKWARD LINKAGES IMPACT OF TECHNOLOGICAL CHANGE: IMPLEMENTATION OF SHRIMP MARICULTURE

NUMBER OF SECTORS AFFECTED AND DIRECTION OF CHANGE (1)

Change in Total Backward Linkages	A	B	C	D	E
decrease	1	0	1	26	10
increase	92	93	92	57	74
no change	0	0	0	10	9

CUMULATIVE EFFECT ON ECONOMY (2)

	A	B	C	D	E
decrease	0.03	0	0.00	0.26	0.00
increase	7.62	7.88	8.05	0.01	0.28
net change	7.58	7.88	8.05	-0.2	0.28

Source: Summarized by author from appendix 1.A.

(1) Captures how each sector responded to the stimulus, relative to the 1980 economy, by registering any decrease or increase in the total backward linkage.
(2) Measures the net change registered, relative to the 1980 economy, in the economic system as a result of the technological change.

Simulations:

A. OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITH THE FISHERIES SECTOR PRODUCING NORMAL OUTPUT.
B. CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITH FISHERY SECTOR OPERATING NORMALLY.
C. CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER ACTIVITY IN THE FISHERIES SECTOR.
D. OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER OUTPUT FROM THE FISHERIES SECTOR.
E. OPERATION OF SHRIMP FLEET WITHOUT ANY OTHER PRODUCTION FROM FISHERIES SECTOR.

generates net positive linkages in the economy, while the operation of the shrimp ponds generates a reduction in the total backward linkages in the economy. As noted earlier, this may be due to the relative importance of the value added of the aquaculture production. Another aspect that may contribute to the decreased backward linkage impact of the aquaculture sector may be the relatively primary nature of its inputs. By drawing from inputs that have not yet gone through transformations, aquaculture may not contribute to high backward linkage industries. For example, while the fishery may draw from sectors such as cotton, it does so indirectly by purchasing from the soft fibers industry that have cleaned, processed, treated, woven, and knotted the cotton into nets. In the case of aquaculture, the purchases tend to be more direct and with less transformations, for example soybeans and corn for feed.

To analyze the coefficient of variation of backward linkages, we turn to Table 11, which measures the dispersion of the backward linkage throughout the economic system. We found that the production of shrimp through aquaculture improved the dispersion of the linkages of the sectors in the economy. In contrast, the operation of the shrimp vessels contributed to a reduction the dispersion of the backward linkage. The significance of the contribution by the aquaculture production may be attributed to the diversified inputs into the production process, particularly primary products such as corn and soybean. For example, aquaculture production draws from many of the same sectors as the fishery, as well as agriculture based sector, and to itself (as fishmeal in balanced feed).

TABLE 11. SUMMARY OF IMPACT OF TECHNOLOGICAL CHANGE ON COEFFICIENT OF VARIATION OF TOTAL BACKWARD LINKAGES

NUMBER OF SECTORS AFFECTED AND DIRECTION OF CHANGE (1)

	A	B	C	D	E
decrease in dispersion	20	5	54	34	10
increase in dispersion	23	38	83	25	45
no change in dispersion	50	50	29	59	38

CUMULATIVE EFFECT ON ECONOMY (2)

	A	B	C	D	E
decrease	-0.35315	-0.00359	-0.34865	-1.31205	-0.00307
increase	0.082170	0.764483	1.337732	0.055356	0.964956
absolute change	-0.27098	0.760887	0.989076	-1.25669	0.961878

Source: Summarized by author from Appendix 1.B

(1) Captures how each sector responded to the stimulus, relative to the 1980 economy, by registering any change in the degree that the backward linkage is dispersed over the economy.
(2) Measures the net change in the dispersion of the linkages to the economic system. In the table, a negative absolute change refers to an increase in the coefficient of variation, which is a decrease in dispersion.

Simulations:

A. OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITH THE FISHERIES SECTOR PRODUCING NORMAL OUTPUT.
B. CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITH FISHERY SECTOR OPERATING NORMALLY.
C. CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER ACTIVITY IN THE FISHERIES SECTOR.
D. OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER OUTPUT FROM THE FISHERIES SECTOR.
E. OPERATION OF SHRIMP FLEET WITHOUT ANY OTHER PRODUCTION FROM FISHERIES SECTOR.

The strength of the total backward linkages that are stimulated in the Mexican economy--through the shrimp fishery and shrimp aquaculture--are comparable, as shown in Table 12. As reflected in the power of dispersion, both technologies stimulate increases in the total backward linkage of 91 out of the 93 included in the input-output matrix. Since the measure registers changes in the strength of the backward linkage relative to the average linkage in the economy (see Chapter 4), the cumulative effect of the increases and decreases offset each other. In this sense, the relevant measure would be the relative ranking of the sectors themselves and not the measure. However, the expenditure is not of a sufficient magnitude to generate changes in the relative strength of the most important backward linkage sectors.

CONCLUSION

In this chapter, we have presented the linkage profile of the Mexican fisheries sector. The sector purchases inputs from 29 out of the 93 sectors in the input-output table and has important backward linkages. The shrimp fishery contributes to the backward linkage of the sector by generating over 40% of the purchases of the sector. We found that the backward linkage generated by the construction of the shrimp farming infrastructure would correspond to the fifth largest linkage in the economy in 1980. In addition, if we compare the summation of the linkages generated by the current-account expenditures for the operation of the farms, we see that capital-expenditures generate a greater linkage than those on current account. Although the procedure of comparing linkages by

TABLE 12 SUMMARY OF THE IMPACT OF TECHNOLOGICAL CHANGE ON THE POWER OF DISPERSION OF TOTAL BACKWARD LINKAGES

NUMBER OF SECTORS AFFECTED AND DIRECTION OF CHANGE (1)

	A	B	C	D	E
increase	90	2	1	91	91
decrease	3	91	92	2	2

CUMULATIVE EFFECT ON ECONOMY (2)

	A	B	C	D	E
increase	-0.05188	-0.12245	-0.27127	-0.16555	-0.17407
decrease	0.051887	0.122452	0.271277	0.165553	0.174073

Source: Summarized by author from appendix 1.C.

(1) Indicates changes in the relative strength, to the baseline 1980 economy, of the backward linkages generated by the change in technology.

(2) Indicates the absolute changes in the backward linkage profile of the economy. The numbers represent the net movement of linkages around the mean linkage in the economy.

Simulations:

A. OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITH THE FISHERIES SECTOR PRODUCING NORMAL OUTPUT.
B. CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITH FISHERY SECTOR OPERATING NORMALLY.
C. CONSTRUCTION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER ACTIVITY IN THE FISHERIES SECTOR.
D. OPERATION OF 90,000 HECTARES OF SHRIMP PONDS WITHOUT ANY OTHER OUTPUT FROM THE FISHERIES SECTOR.
E. OPERATION OF SHRIMP FLEET WITHOUT ANY OTHER PRODUCTION FROM FISHERIES SECTOR.

summing future linkages may not fit with standard analytical procedures, it does provide us with an insight into the impact of the capital expenditures.

We also compared the linkages generated by the current-account expenditures of shrimp aquaculture and the shrimp fishery. From our calculations we believe that the shrimp fishery has stronger total backward linkages than shrimp aquaculture with the Mexican economy, but shrimp aquaculture generated total backward linkages that are dispersed throughout the economic system more evenly than the fishery-generated linkages.

CHAPTER 8

INTERPRETATIONS AND CONCLUSIONS

In this study we sought to define how the implementation of a new production technology that expands the capacity of a supply-constrained natural resource will affect an economic system. Two major factors have been discussed, the qualitative institutional framework and the quantitative structure of the economy.

INSTITUTIONAL FRAMEWORK

The most critical qualitative factor that defines the production strategy is the institutional framework as manifested in the definition of property rights. The nature of the technological change, which challenged the existing institutional and legal statutes, has generated institutional reform. The institutional reform had been seen by many as a necessary condition for the development of shrimp farming. Indeed, the failure of major farms served as empirical evidence of the incompatible nature of the production technology and the institutional framework. In this regard, we propose that it was the closed and restricted nature of the aquaculture resource that prevented the aquaculture resource from being developed. Paradoxically, it was the closed and protected nature of the fishery that led to its overcapitalization. In effect, if the policies had been reversed, we may have seen a more rational development.

The policies that have failed to generate sustainable development have been formulated by the policy-makers in a political framework. Although politics should play a critical role in the formulation of development policy, policy makers must realize that industries that are based on natural resources may not withstand political initiatives. A second major institutional factor that defines the two production technologies is the wages and salary structure. Although wages and salaries based on the value of production appear to be an attractive proposition for workers, the overcapitalization of the sector, concurrent with this wage strategy--generates a fragile and a low-pay wage structure. If the wages paid were to conform to the regional wages, it appears that the jobs created would be more viable.

STRUCTURE OF THE ECONOMY

The intersectoral relationships that are generated through the cultivation of shrimp differ substantially from the fishery. The major difference is that the agricultural sector provides inputs for the production of balanced feed for shrimp. Given the nature of the balanced feed sector as well as that of the agricultural sector, it is imperative that coordination among the sectors take place. Although this conclusion may be clearly evident from the national accounts, the coexistence of agricultural deficits and vast shrimp potentials in the same region could create undesirable effects. For example, crops normally grown for self consumption could be switched to the husbandry of the shrimp. This problem would be especially evident is the southeastern states of Chiapas and Oaxaca.

Another problem will be the temporal nature of the linkages associated with aquaculture development. Given the magnitude of labor required during harvesting, a lack of coordination could result in significant modification in the rural wage and in the production of traditional crops. For example, many of the shrimp-harvesting operations coincide with the planting season for agriculture crops. If subsistence or small scale farmers delay their sowing and seeding, due to the high daily wages of the shrimp harvest, then the welfare of the farmers could suffer.

From the intersectoral impact analysis, we found that the production of shrimp through aquaculture will indirectly affect sectors that would not have been identifiable through a partial equilibrium analysis. Although the magnitude of the impact in many of the sectors is very insignificant, it does indicate that regional economies that lack sectors or access to sectors will have to go outside their region for specific inputs.

From the perspective of the intersectoral relationships of the production technologies, the input-output technique has permitted us to identify and quantify the sectors affected by the production of shrimp through fishery and aquaculture-based production techniques. However, the level of aggregation of the matrix, as well as the limited data for the inputs of the shrimp vessels constrain the prescriptive conclusions that we can make. The linkage analysis does nevertheless provide an insight into the magnitude of the impact that the production process will have upon the economic system and on particular sectors.

An important aspect of the study is the independent treatment of capital and recurrent costs. By identifying the sectors affected by capital as well as recurring costs, we were able to consider capital and recurrent linkages. The importance of considering the recurring nature of the operating expenditures generated linkages permitted us to obtain a more complete understanding of the impact that a capital expenditure may have upon an economic system. Indeed, a viable analytical tool could consider the linkages derived from the operation of capital investments as a true measure of the impact of the investment on the economic system

REGIONAL IMPACT

In this study, we have attempted to develop an understanding of the impact of the emergence of a rural industry. From a national perspective, the insight that can be developed through the input-output table is important. Given the fact that a few states in Mexico have the majority of the shrimp farming potential, the analysis could be adapted to a regional development impact study. By identifying the relative participation of the sectors affected by the shrimp farm development--in the states where the development will take place--state planning officials may attempt to capture the linkages generated by the activity in their own region.

We believe that regional applications of the methods developed in this study could help in planning the development of the shrimp farms in the States of Sinaloa and Chiapas. These two states have the potential to absorb and make productive an expenditure of the magnitude being proposed in this study; however, they are not industrialized and would have to import any nonagricultural input. Thus, the benefits generated by the linkages would be exported. A special development case is that of the state of Oaxaca. As one of the poorest and most culturally diverse states, Oaxaca would probably not fit well into the development model presented in this study. The small plots of land, capital-constrained economy, and lack of basic infrastructure would dictate an artisinal approach, both in the operation and in the construction of the shrimp farms. Thus, any conclusions that may be derived from this study should be analyzed in the context of the regional economy that is going to be subject to shrimp farm development.

FINAL CONSIDERATIONS

Without doubt, the study could be refined and improved. By considering the forward linkages, installed capacity of infrastructure, regional wage and input data, valorization of the land, the externalities generated by the physical infrastructure, import component of inputs, rural wage effects, the production cost of post-larvae among others, we could obtain a more complete understanding of the impact of shrimp farm development. Given time and data constraints, we present this study as a modest example of future work to be developed and improved by research teams in Mexico.

Finally, we believe it is imperative to close by looking at those who could benefit from the shrimp farm development. Although much of the land suitable for shrimp farms is under federal jurisdiction, some of the best plots, many of them several thousands acres each, are owned by very poor persons. The transformation of these goat farmers and artisinal fishers into productive and potentially wealthy shrimp farmers may be the most interesting transformation that the technological change may generate. The inability of the fisher to pass on his/her trade to their children rests on the limits of the natural resource. Technological change may be the key so that the fisher or the goat farmer may leave their children an opportunity to work on the land where they were born.

APPENDICES

SECTOR DECOMPOSTION OF 1980 MEXICAN INPUT-OUTPUT TABLE

1a	CORN	27	CLOTHES
1b	RICE	28	LEATHER AND ITS PRODUCTS
1c	WHEAT	29	SAWMILLS INCLUDING COMPOSITES
1d	BEANS	30	OTHER WOOD INDUSTRIES
1e	SORGUM	31	PAPER AND CARTON
1f	BARLEY	32	PUBLISHING AND PRINTING
1g	SOY BEANS	33	PETROLEUM REFINERIES
1h	SAFFLOWER	34	BASIC PETROCHEMICAL
1i	SESAME	35	BASIC CHEMICAL PRODUCTS
1j	COTTON	36	MANURE AND FERTILIZERS
1k	SUGAR CANE	37	SYNTHETIC RESINS, PLASTICS, ARTIFICIAL FIBERS
1l	COFEE	38	MEDICAL PRODUCTS
1m	TABACCO	39	SOAPS, DETERERGENTS, PERFUMES, COSMETICS
1n	CACAO	40	OTHER CHEMICAL INDUSTRIES
1o	SISAL	41	RUBBER PRODUCTS
1p	OTHER AGRICULTURE PRODUCTS	42	PLASTIC PRODUCTS
2a	CATTLE	43	GLASS AND ITS PRODUCTS
2b	PORK	44	CEMENT
2c	SHEEP AND GOATS	45	OTHER NON METALIC MINERAL PRODUCTS
2d	POULTRY	46	BASIC STEEL AND IRON INDUSTRIES
2e	BEEKEEPING	47	BASIC NONFERRIC METAL INDUSTRIES
2f	OTHER LIVESTOCK	48	STEEL FURNITURE AND ACCESORIES
3a	FORESTY-WOOD PRODUCTION	49	STEEL STRUCTURAL PRODUCTS
3b	FORESTRY-NON WOOD PRODUCTS	50	OTHER STEEL PRODUCTS
4	FISHERIES AND GAME	51	INDUSTRIAL ELECTRIC EQUIPMENT
5	COAL AND ITS DERIVATIVES	52	INDUSTRIAL ELECTRIC MACHINERY
6	EXTRACTION OF PETROLEUM AND GAS	53	DOMESTIC ELECTRIC EQUIPMENT
7	STEEL MINING	54	ELECTRONIC EQUIPMENT AND ACCESORIES
8	NON FERRIC METAL MINERALS	55	OTHER ELECTRONIC EQUIPMNET AND APPLIENCES
9	SAND, GRAVEL, AND CLAY	56	AUTOMOBILES
10	OTHER NON-METALIC PRODUCTS	57	AUTO BODIES AND PARTS
11	MEAT AND MILK BASED FOOD	58	OTHER TRANSPORTATION
12	FRUIT AND VEGETABLE PROCESSING	59	OTHER MANUFACTURING INDUSTRIES
13	WHEAT MILLING AND ITS DERIVATIVES	60	CONSTRUCTION
14	NIXTAMAL MILLING & CORN PRODUCTS	61	ELECTRICITY
15	COFFEE PROCESSING	62	COMMERCE (TRADE)
16	SUGAR AND SUGAR PRODUCTS	63	RESTAURANTS AND HOTELS
17	VEGETABLE OIL FOR HUMAN CONSUMPTION	64	TRANSPORTATION
18	ANIMAL FEED	65	COMMUNICATIONS
19	OTHER FOOD PRODUCTS	66	FINANCIAL SERVICES
20	ALCOHOLIC BEVERAGES	67	LEASED REAL STATE
21	BEER	68	PROFESSIONAL SERVICES
22	BOTTLED SOFTDRINKS	69	EDUCATIONAL SERVICES
23	TABACCO AND ITS PRODUCTS	70	MEDICAL SERVICES
24	WEAVING & SPINNING OF SOFT FIBERS	71	ENTRETAINMENT SERVICES
25	WEAVING & SPINNING OF HARD FIBERS	72	OTHER SERVICES
26	OTHER TEXTILE INDUSTRIES		

SOURCE: Instituto Nacional de Estadistica Geografia e Informatica (1988).

APPENDIX 1.A. TOTAL BACKWARD LINKAGE OF 1980 MEXICAN ECONOMY AND SIMULATION OF TECHNOLOGICAL CHANGE

							DIFFERENCE FROM BASELINE				
SECTORS	BASELINE	A	B	C	D	E	A	B	C	D	E
1a	1.25808	1.28319	1.28319	1.28319	1.25809	1.25809	-0.02511	-0.02511	-0.02511	-0.00001	-0.00001
1b	1.37597	1.41725	1.41726	1.41724	1.37594	1.37594	-0.04128	-0.04129	-0.04127	0.00003	0.00003
1c	1.41223	1.44974	1.44974	1.44974	1.41224	1.41224	-0.03751	-0.03751	-0.03751	-0.00001	-0.00001
1d	1.16358	1.18594	1.18594	1.18594	1.16357	1.16357	-0.02236	-0.02236	-0.02236	0.00001	0.00001
1e	1.32386	1.38042	1.38042	1.38041	1.32423	1.32423	-0.05656	-0.05656	-0.05655	-0.00037	-0.00037
1f	1.50105	1.54743	1.54744	1.54743	1.50107	1.50107	-0.04638	-0.04639	-0.04638	-0.00002	-0.00002
1g	1.34082	1.37743	1.37743	1.37743	1.34085	1.34086	-0.03661	-0.03661	-0.03661	-0.00003	-0.00004
1h	1.22824	1.23968	1.23968	1.23968	1.22829	1.22829	-0.01144	-0.01144	-0.01144	-0.00005	-0.00005
1i	1.37502	1.40396	1.40396	1.40397	1.37503	1.37504	-0.02894	-0.02894	-0.02895	-0.00001	-0.00002
1j	1.28703	1.31292	1.31293	1.31291	1.28704	1.28704	-0.02589	-0.0259	-0.02588	-0.00001	-0.00001
1k	1.33271	1.36936	1.36936	1.36936	1.33272	1.33272	-0.03665	-0.03665	-0.03665	-0.00001	-0.00001
1l	1.08037	1.08692	1.08692	1.08692	1.08039	1.08039	-0.00655	-0.00655	-0.00655	-0.00002	-0.00002
1m	1.45006	1.48115	1.48116	1.48114	1.4501	1.4501	-0.03109	-0.0311	-0.03108	-0.00004	-0.00004
1n	1.2147	1.24487	1.24487	1.24486	1.21472	1.21472	-0.03017	-0.03017	-0.03016	-0.00002	-0.00002
1o	1.05344	1.05798	1.05798	1.05798	1.05346	1.05346	-0.00454	-0.00454	-0.00454	-0.00002	-0.00002
1p	1.19857	1.22478	1.22477	1.22477	1.1986	1.1986	-0.02621	-0.0262	-0.0262	-0.00003	-0.00003
2a	1.58394	1.65701	1.65687	1.65637	1.58513	1.58404	-0.07307	-0.07293	-0.07243	-0.00119	-0.0001
2b	1.65943	1.72637	1.72626	1.72597	1.66031	1.65956	-0.06694	-0.06683	-0.06654	-0.00088	-0.00013
2c	1.18973	1.22118	1.22099	1.22088	1.19035	1.18979	-0.03145	-0.03126	-0.03115	-0.00062	-0.00006
2d	1.77394	1.86346	1.86331	1.86302	1.77507	1.77411	-0.08952	-0.08937	-0.08908	-0.00113	-0.00017
2e	1.07465	1.07947	1.07979	1.07863	1.07376	1.07434	-0.00482	-0.00514	-0.00398	0.00089	0.00031
2f	1.43308	1.47404	1.47406	1.47401	1.43314	1.43313	-0.04096	-0.04098	-0.04093	-0.00006	-0.00005
3a	1.34552	1.37314	1.37314	1.37313	1.34609	1.34609	-0.02762	-0.02762	-0.02761	-0.00057	-0.00057
3b	1.02363	1.02591	1.02591	1.02591	1.02366	1.02366	-0.00228	-0.00228	-0.00228	-0.00003	-0.00003
4	1.48606	1.44699	1.71549	1.99745	1.25147	1.73401	0.03907	-0.22943	-0.51139	0.23459	-0.24795
5	1.67645	1.73038	1.73038	1.73038	1.67642	1.67642	-0.05393	-0.05393	-0.05393	0.00003	0.00003
6	1.13415	1.17603	1.17604	1.17602	1.13417	1.13418	-0.04188	-0.04189	-0.04187	-0.00002	-0.00003
7	1.27754	1.3307	1.3307	1.3307	1.27752	1.27753	-0.05316	-0.05316	-0.05316	0.00002	0.00001
8	1.7459	1.7888	1.7888	1.7888	1.7459	1.7459	-0.0429	-0.0429	-0.0429	0	0
9	1.17851	1.1878	1.18779	1.18779	1.17852	1.17852	-0.00929	-0.00928	-0.00928	-0.00001	-0.00001
10	1.23478	1.2813	1.2813	1.2813	1.2348	1.2348	-0.04652	-0.04652	-0.04652	-0.00002	-0.00002
11	2.24119	2.31753	2.31744	2.31706	2.2419	2.24132	-0.07634	-0.07625	-0.07587	-0.00071	-0.00013
12	1.87763	1.95436	1.95477	1.95346	1.87727	1.87805	-0.07673	-0.07714	-0.07583	0.00036	-0.00042
13	1.87097	1.99615	1.99694	1.99434	1.87036	1.87166	-0.12518	-0.12597	-0.12337	0.00061	-0.00069
14	1.81765	2.1076	2.1076	2.1076	1.81765	1.81766	-0.28995	-0.28995	-0.28995	0	-0.00001
15	1.87597	1.8889	1.88894	1.8889	1.87602	1.87606	-0.01293	-0.01297	-0.01293	-0.00005	-0.00009
16	1.52083	1.55586	1.55586	1.55587	1.52082	1.52082	-0.03503	-0.03503	-0.03504	0.00001	0.00001
17	1.76666	1.96184	1.96196	1.96162	1.76658	1.76678	-0.19518	-0.1953	-0.19496	0.00008	-0.00012
18	1.59699	2.00378	2.00178	2.00048	1.60619	1.59731	-0.40679	-0.40479	-0.40349	-0.0092	-0.00032
19	1.77647	1.83972	1.86746	1.76966	1.75223	1.80212	-0.06325	-0.09099	0.00681	0.02424	-0.02565
20	1.65411	1.67712	1.67721	1.67684	1.65404	1.65423	-0.02301	-0.0231	-0.02273	0.00007	-0.00012
21	1.75249	1.79691	1.79699	1.7966	1.75236	1.75254	-0.04442	-0.0445	-0.04411	0.00013	-0.00005
22	1.50988	1.68031	1.68254	1.67464	1.50787	1.51189	-0.17043	-0.17266	-0.16476	0.00201	-0.00201
23	1.48162	1.50583	1.50583	1.50582	1.48165	1.48165	-0.02421	-0.02421	-0.0242	-0.00003	-0.00003
24	1.85946	1.91593	1.91593	1.91588	1.85952	1.85954	-0.05647	-0.05647	-0.05642	-0.00006	-0.00008
25	1.51712	1.54033	1.54033	1.54033	1.51713	1.51713	-0.02321	-0.02321	-0.02321	-0.00001	-0.00001
26	1.76022	1.85277	1.85278	1.85275	1.76019	1.7602	-0.09255	-0.09256	-0.09253	0.00003	0.00002

(CONTINUES) FOR AN EXPLANATION OF SIMULATIONS A, B, C, D, AND E; PLEASE REFER TO TABLE 10

APPENDIX 1.A. TOTAL BACKWARD LINKAGE OF 1980 MEXICAN ECONOMY AND SIMULATION OF TECHNOLOGICAL CHANGE (Continued)

							DIFFERENCE FROM BASELINE				
SECTORS	baseline	A	B	C	D	E	A	B	C	D	E
27	1.8701	1.9204	1.9204	1.92038	1.8701	1.87011	-0.0503	-0.0503	-0.05028	0	-0.00001
28	1.81882	1.89677	1.89727	1.89569	1.8184	1.8193	-0.07795	-0.07845	-0.07687	0.00042	-0.00048
29	1.79156	1.81215	1.81215	1.81216	1.79173	1.79174	-0.02059	-0.02059	-0.0206	-0.00017	-0.00018
30	1.74877	1.80919	1.8092	1.80919	1.7488	1.74881	-0.06042	-0.06043	-0.06042	-0.00003	-0.00004
31	1.73822	1.90477	1.90479	1.90471	1.73824	1.73828	-0.16655	-0.16657	-0.16649	-0.00002	-0.00006
32	1.62247	1.7443	1.74431	1.74426	1.62248	1.62248	-0.12183	-0.12184	-0.12179	-0.00001	-0.00001
33	1.88052	1.95774	1.95775	1.95774	1.88052	1.88053	-0.07722	-0.07723	-0.07722	0	-0.00001
34	1.81956	1.90556	1.90558	1.90551	1.81955	1.81957	-0.086	-0.08602	-0.08595	0.00001	-0.00001
35	1.47535	1.69985	1.69986	1.69981	1.47536	1.47537	-0.2245	-0.22451	-0.22446	-0.00001	-0.00002
36	1.91473	2.06544	2.06544	2.06544	1.91475	1.91475	-0.15071	-0.15071	-0.15071	-0.00002	-0.00002
37	1.78558	1.98753	1.98753	1.98753	1.78561	1.78561	-0.20195	-0.20195	-0.20195	-0.00003	-0.00003
38	1.45626	1.64638	1.64649	1.6461	1.45617	1.45634	-0.19012	-0.19023	-0.18984	0.00009	-0.00008
39	1.72047	1.88214	1.88219	1.8821	1.72049	1.72048	-0.16167	-0.16172	-0.16163	-0.00002	-0.00001
40	1.68081	1.88763	1.88769	1.88752	1.68082	1.68087	-0.20682	-0.20688	-0.20671	-0.00001	-0.00006
41	1.60343	1.74351	1.74351	1.7435	1.60345	1.60346	-0.14008	-0.14008	-0.14007	-0.00002	-0.00003
42	1.45682	1.70259	1.70259	1.70258	1.45679	1.4568	-0.24577	-0.24577	-0.24576	0.00003	0.00002
43	1.60526	1.66968	1.66968	1.66967	1.60526	1.60527	-0.06442	-0.06442	-0.06441	0	-0.00001
44	1.69543	1.73175	1.73175	1.73174	1.69544	1.69545	-0.03632	-0.03632	-0.03631	-0.00001	-0.00002
45	1.51656	1.57714	1.57714	1.57714	1.51656	1.51656	-0.06058	-0.06058	-0.06058	0	0
46	1.96274	2.13808	2.13808	2.13809	1.96275	1.96275	-0.17534	-0.17534	-0.17535	-0.00001	-0.00001
47	1.8142	1.94981	1.94981	1.94981	1.81421	1.81421	-0.13561	-0.13561	-0.13561	-0.00001	-0.00001
48	1.82159	1.93027	1.93028	1.93026	1.82158	1.82159	-0.10868	-0.10869	-0.10867	0.00001	0
49	1.78432	1.86521	1.86521	1.86521	1.78438	1.78438	-0.08089	-0.08089	-0.08089	-0.00006	-0.00006
50	1.44138	1.68597	1.68597	1.68597	1.44136	1.44137	-0.24459	-0.24459	-0.24459	0.00002	0.00001
51	1.50182	1.70405	1.70405	1.70405	1.50186	1.50186	-0.20223	-0.20223	-0.20223	-0.00004	-0.00004
52	1.64209	1.77323	1.77323	1.77323	1.64208	1.64209	-0.13114	-0.13114	-0.13114	0.00001	0
53	1.75555	1.84327	1.84328	1.84327	1.75557	1.75557	-0.08772	-0.08772	-0.08772	-0.00002	-0.00002
54	1.65759	1.80464	1.80464	1.80464	1.65759	1.65759	-0.14705	-0.14705	-0.14705	0	0
55	1.55216	1.71882	1.71882	1.71882	1.55216	1.55216	-0.16666	-0.16666	-0.16666	0	0
56	1.7397	1.99752	1.99752	1.99751	1.73972	1.73972	-0.25782	-0.25782	-0.25781	-0.00002	-0.00002
57	1.7886	1.91919	1.91919	1.91917	1.78864	1.78864	-0.13059	-0.13059	-0.13057	-0.00004	-0.00004
58	1.61561	1.73564	1.73564	1.73562	1.6156	1.61561	-0.12003	-0.12003	-0.12001	0.00001	0
59	1.54792	1.67636	1.67637	1.67633	1.5479	1.54793	-0.12844	-0.12845	-0.12841	0.00002	-0.00001
60	1.78286	1.8627	1.8627	1.86269	1.78286	1.78287	-0.07984	-0.07984	-0.07983	0	-0.00001
61	1.52672	1.56208	1.56208	1.56207	1.52672	1.52672	-0.03536	-0.03536	-0.03535	0	0
62	1.20575	1.21634	1.21634	1.21634	1.20581	1.20581	-0.01059	-0.01059	-0.01059	-0.00006	-0.00006
63	1.2741	1.28158	1.28158	1.28158	1.27413	1.27413	-0.00748	-0.00748	-0.00748	-0.00003	-0.00003
64	1.36827	1.45596	1.45596	1.45595	1.36824	1.36824	-0.08769	-0.08769	-0.08768	0.00003	0.00003
65	1.16004	1.21368	1.21368	1.21368	1.16005	1.16005	-0.05364	-0.05364	-0.05364	-0.00001	-0.00001
66	1.29435	1.30895	1.30895	1.30895	1.2944	1.2944	-0.0146	-0.0146	-0.0146	-0.00005	-0.00005
67	1.11203	1.11557	1.11557	1.11557	1.11208	1.11208	-0.00354	-0.00354	-0.00354	-0.00005	-0.00005
68	1.27057	1.27852	1.27852	1.27852	1.27057	1.27057	-0.00795	-0.00795	-0.00795	0	0
69	1.18525	1.19553	1.19554	1.1955	1.18528	1.18529	-0.01028	-0.01029	-0.01025	-0.00003	-0.00004
70	1.36725	1.39882	1.39911	1.39786	1.36698	1.36746	-0.03157	-0.03186	-0.03061	0.00027	-0.00021
71	1.41973	1.45	1.45	1.45	1.41975	1.41974	-0.03027	-0.03027	-0.03027	-0.00002	-0.00001
72	1.38309	1.41069	1.41069	1.41068	1.38312	1.38313	-0.0276	-0.0276	-0.02759	-0.00003	-0.00004

Source: Calculated by author from INEGI, 1988.

APPENDIX 1.B. CALCULATION OF COEFICIENT OF VARIATION OF TOTAL BACKWARD LINKAGE THE ECONOMY OF MEXICO. AND SIMULATION OF TECHNOLOGICAL CHANGE

SECTOR	BASELINE	A	B	C	D	E	DIFFERENCE FROM BASELINE A	B	C	D	E
1a	7.7927	7.7927	7.7927	7.7927	7.7927	7.7927	0.0000	0.0000	0.0000	0.0001	0.0000
1b	7.2602	7.2603	7.2602	7.2603	7.2603	7.2603	-0.0001	0.0000	-0.0001	-0.0001	-0.0001
1c	7.0723	7.0723	7.0723	7.0723	7.0723	7.0723	0.0000	0.0000	0.0000	0.0000	0.0000
1d	8.4247	8.4247	8.4247	8.4247	8.4247	8.4247	0.0000	0.0000	0.0000	0.0000	0.0000
1e	7.3154	7.3135	7.3135	7.3135	7.3135	7.3135	0.0019	0.0019	0.0019	0.0019	0.0019
1f	6.7646	6.7646	6.7646	6.7646	6.7646	6.7646	0.0000	0.0000	0.0000	0.0000	0.0000
1g	7.4003	7.4003	7.4003	7.4003	7.4003	7.4003	0.0000	0.0000	-0.0000	0.0000	0.0000
1h	8.0584	8.0584	8.0584	8.0584	8.0584	8.0584	0.0000	0.0000	0.0000	0.0000	0.0000
1i	7.0944	7.0944	7.0944	7.0944	7.0944	7.0944	0.0000	0.0000	0.0001	0.0000	0.0001
1j	7.6839	7.6839	7.6839	7.6840	7.6839	7.6839	0.0000	0.0001	-0.0001	0.0000	0.0001
1k	7.4888	7.4888	7.4888	7.4888	7.4888	7.4888	0.0000	0.0000	0.0000	0.0000	0.0000
1l	9.0170	9.0170	9.0170	9.0170	9.0170	9.0170	0.0000	0.0000	0.0000	0.0000	0.0000
1m	6.7837	6.7837	6.7837	6.7838	6.7837	6.7837	0.0000	0.0000	-0.0000	0.0000	0.0000
1n	7.9543	7.9543	7.9543	7.9544	7.9542	7.9543	0.0000	0.0000	-0.0001	0.0001	0.0000
1o	9.1649	9.1649	9.1649	9.1647	9.1649	9.1649	0.0000	0.0000	0.0000	0.0000	0.0000
1p	8.1436	8.1436	8.1436	8.1436	8.1436	8.1426	0.0001	0.0000	0.0000	0.0001	0.0000
2a	6.1884	6.1812	6.1879	6.1900	6.1834	6.1880	0.0072	0.0004	-0.0017	0.0049	0.0004
2b	5.8941	5.8896	5.8937	5.8948	5.8909	5.8936	0.0045	0.0004	-0.0006	0.0032	0.0005
2c	8.1110	8.1048	8.1108	8.1116	8.1068	8.1110	0.0062	0.0002	-0.0006	0.0043	0.0001
2d	5.5775	5.5724	5.5770	5.5779	5.5738	5.5770	0.0051	0.0005	-0.0004	0.0037	0.0005
2e	9.0153	9.0212	9.0187	9.0289	9.0228	9.0179	-0.0060	-0.0034	-0.0136	-0.0075	-0.0026
2f	6.7521	6.7517	6.7519	6.7522	6.7518	6.7519	0.0003	0.0001	-0.0001	0.0003	0.0002
3a	7.1703	7.1674	7.1674	7.1675	7.1675	7.1674	0.0029	0.0029	0.0028	0.0028	0.0029
3b	9.4193	9.4193	9.4193	9.4193	9.4193	9.4193	0.0000	0.0000	0.0000	0.0000	0.0000
4	6.5117	6.8349	5.8327	5.1794	7.7377	5.5680	-0.3232	0.6790	1.3323	-1.2260	0.8438
5	7.9223	7.9223	7.9223	7.9223	7.9223	7.9223	0.0000	0.0000	0.0000	0.0000	0.0000
6	8.5342	8.5342	8.5341	8.5343	8.5341	8.5340	0.0000	0.0001	-0.0001	0.0001	0.0002
7	8.5012	8.5012	8.5012	8.5012	8.5012	8.5012	0.0000	0.0000	0.0000	0.0000	0.0000
8	8.1139	8.1139	8.1139	8.1139	8.1139	8.1139	0.0000	0.0000	0.0000	0.0000	0.0000
9	8.2218	8.2218	8.2219	8.2219	8.2219	8.2219	0.0000	-0.0001	-0.0001	-0.0001	-0.0001
10	7.9043	7.9043	7.9043	7.9043	7.9043	7.9043	0.0000	0.0000	0.0000	-0.0000	0.0000
11	4.7836	4.7860	4.7884	4.7893	4.7868	4.7893	0.0026	0.0003	-0.0006	0.0018	0.0003
12	5.4099	5.4092	5.4081	5.4126	5.4098	5.4090	-0.0003	0.0008	-0.0037	-0.0009	-0.0001
13	6.0067	6.0072	6.0050	6.0139	6.0086	6.0043	-0.0006	0.0016	-0.0073	-0.0019	0.0023
14	7.9852	7.9852	7.9852	7.9852	7.9852	7.9852	0.0000	0.0000	0.0000	0.0000	0.0000
15	6.5127	6.5127	6.5126	6.5127	6.5126	6.5125	-0.0001	0.0001	-0.0001	0.0000	0.0002
16	6.6890	6.6890	6.6890	6.6890	6.6890	6.6890	0.0000	0.0000	0.0000	0.0000	0.0000
17	5.8030	5.8031	5.8027	5.8040	5.8032	5.8026	-0.0001	0.0003	-0.0010	-0.0002	0.0004
18	6.1078	6.0575	6.1068	6.1121	6.0764	6.1064	0.0503	0.0010	-0.0043	0.0314	0.0014
19	5.6409	5.6601	5.5768	5.9063	5.7039	5.5463	-0.0192	0.0642	-0.2654	-0.0630	0.0947
20	6.3335	6.3335	6.3332	6.3347	6.3337	6.3331	-0.0000	0.0002	-0.0013	-0.0003	0.0003
21	5.9073	5.9074	5.9072	5.9085	5.9076	5.9071	-0.0001	0.0001	-0.0012	-0.0003	0.0002
22	6.4183	6.4210	6.4122	6.4475	6.4264	6.4093	-0.0027	0.0061	-0.0292	-0.0081	0.0090
23	7.0436	7.0436	7.0436	7.0436	7.0436	7.0436	0.0000	0.0000	-0.0000	-0.0000	-0.0000
24	6.0746	6.0745	6.0745	6.0747	6.0746	6.0745	0.0001	0.0000	-0.0001	0.0000	0.0001
25	7.5510	7.5510	7.5510	7.5510	7.5510	7.5510	0.0000	0.0000	0.0000	0.0000	0.0000
26	5.8131	5.8131	5.8131	5.8132	5.8132	5.8132	0.0000	0.0000	-0.0001	-0.0000	-0.0000

(CONTINUES) FOR AN EXPLANATION OF THE SIMULATIONS, A, B, C, D, AND E PLEASE REFER TO TABLE 11

APPENDIX 1.B. CALCULATION OF COEFICIENT OF VARIATION OF TOTAL BACKWARD LINKAGE THE ECONOMY OF MEXICO. AND SIMULATION OF TECHNOLOGICAL CHANGE

(CONTINUED)

SECTOR	BASELINE	A	B	C	D	E	DIFFERENCE FROM BASELINE A	B	C	D	E
27	5.5086	5.5086	5.5086	5.5087	5.5086	5.5086	-0.0001	-0.0001	-0.0001	-0.0001	0.0000
28	6.4649	6.4650	6.4636	6.4720	6.4661	6.4630	-0.0001	0.0013	-0.0071	-0.0012	0.0018
29	6.0863	6.0858	6.0858	6.0857	6.0858	6.0857	0.0005	0.0005	0.0005	0.0005	0.0005
30	5.7321	5.7321	5.7321	5.7321	5.7321	5.7321	0.0000	0.0000	0.0000	0.0000	0.0001
31	7.0945	7.0945	7.0944	7.0948	7.0945	7.0942	0.0000	0.0001	-0.0003	0.0000	0.0003
32	6.3489	6.3489	6.3488	6.3490	6.3490	6.3490	0.0000	0.0001	-0.0001	-0.0000	-0.0000
33	6.0940	6.0940	6.0940	6.0940	6.0940	6.0940	-0.0000	0.0000	-0.0000	0.0000	-0.0000
34	5.8731	5.8731	5.8731	5.8733	5.8732	5.8731	-0.0000	0.0000	-0.0002	-0.0001	-0.0000
35	6.7185	6.7185	6.7185	6.7187	6.7186	6.7184	0.0000	0.0000	-0.0002	-0.0000	0.0001
36	5.3249	5.3249	5.3249	5.3249	5.3249	5.3249	0.0000	0.0000	-0.0000	0.0000	0.0000
37	5.7123	5.7123	5.7123	5.7123	5.7123	5.7123	-0.0000	-0.0000	-0.0000	-0.0000	0.0000
38	6.7277	6.7278	6.7274	6.7293	6.7281	6.7274	-0.0001	0.0003	-0.0016	-0.0004	0.0003
39	5.6961	5.6960	5.6960	5.6963	5.6961	5.6961	0.0001	0.0001	-0.0002	0.0000	0.0000
40	6.3876	6.3875	6.3874	6.3590	6.3878	6.3875	0.0000	0.0002	-0.0005	-0.0002	0.0001
41	6.3176	6.3176	6.3176	6.3176	6.3176	6.3176	0.0000	0.0000	-0.0000	-0.0000	0.0000
42	6.7772	6.7772	6.7772	6.7773	6.7772	6.7772	0.0000	0.0000	-0.0000	0.0000	0.0000
43	6.5294	6.5284	6.5294	6.5284	6.5284	6.5284	0.0000	0.0000	-0.0000	0.0000	0.0000
44	5.7680	5.7680	5.7680	5.7680	5.7680	5.7680	0.0000	0.0000	-0.0000	0.0000	0.0000
45	7.1452	7.1452	7.1452	7.1452	7.1452	7.1451	0.0000	0.0000	0.0000	-0.0000	0.0000
46	7.1848	7.1848	7.1848	7.1848	7.1848	7.1848	0.0000	0.0000	0.0000	0.0000	0.0000
47	5.9420	5.9420	5.9420	5.9420	5.9420	5.9420	0.0000	0.0000	0.0000	-0.0000	-0.0000
48	5.4663	5.4663	5.4662	5.4663	5.4663	5.4663	0.0000	0.0001	0.0000	0.0000	0.0000
49	6.1332	6.1332	6.1332	6.1332	6.1332	6.1332	0.0000	0.0000	0.0000	0.0000	0.0000
50	6.7729	6.7729	6.7729	6.7729	6.7729	6.7729	0.0000	0.0000	0.0000	0.0000	0.0000
51	6.6446	6.6446	6.6446	6.6446	6.6446	6.6446	0.0000	0.0000	0.0000	0.0000	0.0000
52	5.9800	5.9800	5.9800	5.9800	5.9800	5.9800	0.0000	0.0000	0.0000	0.0000	0.0000
53	5.9167	5.9167	5.9167	5.9167	5.9167	5.9167	-0.0000	0.0000	-0.0000	-0.0000	0.0000
54	6.2772	6.2772	6.2772	6.2772	6.2772	6.2772	0.0000	0.0000	0.0000	0.0000	0.0000
55	6.2645	6.2645	6.2645	6.2645	6.2645	6.2645	0.0000	0.0000	0.0000	0.0000	0.0000
56	5.7435	5.7435	5.7435	5.7435	5.7435	5.7435	0.0000	0.0000	-0.0000	0.0000	0.0000
57	5.9061	5.9061	5.9061	5.9062	5.9061	5.9061	0.0000	0.0000	-0.0001	0.0000	0.0000
58	6.3151	6.3150	6.3150	6.3151	6.3150	6.3150	0.0000	0.0000	-0.0000	0.0000	0.0001
59	6.3317	6.3316	6.3316	6.3318	6.3317	6.3315	0.0000	0.0001	-0.0001	-0.0000	0.0001
60	5.4689	5.4689	5.4689	5.4689	5.4689	5.4689	-0.0000	-0.0000	-0.0001	-0.0000	0.0000
61	6.8308	6.8308	6.8308	6.8308	6.8308	6.8308	0.0000	0.0000	-0.0000	-0.0000	0.0000
62	8.1151	8.1151	8.1151	8.1151	8.1151	8.1151	0.0000	0.0000	0.0000	0.0000	0.0000
63	7.6274	7.6274	7.6274	7.6274	7.6274	7.6274	0.0000	0.0000	0.0000	0.0000	0.0000
64	7.1944	7.1944	7.1944	7.1945	7.1944	7.1944	0.0000	0.0000	-0.0001	0.0000	0.0000
65	8.3692	8.3692	8.3692	8.3692	8.3692	8.3692	0.0000	0.0000	0.0000	0.0000	0.0000
66	7.5485	7.5485	7.5485	7.5485	7.5485	7.5485	0.0000	0.0000	0.0000	-0.0000	0.0000
67	8.7072	8.7072	8.7072	8.7072	8.7072	8.7072	0.0000	0.0000	0.0000	0.0000	0.0000
68	7.9970	7.9970	7.9970	7.9970	7.9970	7.9970	0.0000	0.0000	0.0000	0.0000	0.0000
69	8.1260	8.1260	8.1259	8.1262	8.1261	8.1257	0.0000	0.0001	-0.0002	-0.0001	0.0003
70	7.0674	7.0679	7.0665	7.0731	7.0688	7.0662	-0.0005	0.0009	-0.0057	-0.0014	0.0012
71	7.7315	7.7314	7.7315	7.7315	7.7315	7.7315	0.0001	0.0000	0.0000	0.0000	0.0000
72	7.1582	7.1582	7.1582	7.1583	7.1583	7.1582	0.0000	0.0000	-0.0001	-0.0001	0.0000

Source: Calculated by author from INEGI, 1998.

APPENDIX 1.C. CALCULATION OF POWER OF DISPERSION FOR MEXICAN ECONOMY AND SIMULATION OF TECHNOLOGICAL CHANGE

							DIFFERENCE FROM BASELINE				
SECTOR	baseline	A	B	C	D	E	A	B	C	D	E
1a	0.82124	0.82160	0.82011	0.81939	0.82268	0.81963	-0.00035	0.00113	0.00184	-0.00144	0.00161
1b	0.89820	0.89858	0.89696	0.89616	0.89976	0.89642	-0.00038	0.00124	0.00203	-0.00156	0.00177
1c	0.92187	0.92227	0.92059	0.91979	0.92348	0.92006	-0.00040	0.00127	0.00207	-0.00161	0.00180
1d	0.75955	0.75988	0.75850	0.75785	0.76088	0.75806	-0.00033	0.00104	0.00170	-0.00132	0.00148
1e	0.86418	0.86480	0.86323	0.86247	0.86593	0.86273	-0.00061	0.00095	0.00170	-0.00175	0.00145
1f	0.97985	0.98027	0.97850	0.97764	0.98156	0.97792	-0.00042	0.00134	0.00220	-0.00171	0.00192
1g	0.87525	0.87563	0.87404	0.87328	0.87678	0.87353	-0.00038	0.00120	0.00196	-0.00153	0.00171
1h	0.80176	0.80211	0.80065	0.79996	0.80316	0.80019	-0.00034	0.00110	0.00180	-0.00140	0.00157
1i	0.89758	0.89797	0.89634	0.89556	0.89915	0.89582	-0.00039	0.00123	0.00201	-0.00157	0.00175
1j	0.84014	0.84050	0.83898	0.83824	0.84161	0.83850	-0.00036	0.00115	0.00189	-0.00146	0.00164
1k	0.86995	0.87034	0.86876	0.86800	0.87148	0.86825	-0.00037	0.00120	0.00195	-0.00152	0.00170
1l	0.70524	0.70554	0.70426	0.70365	0.70647	0.70385	-0.00030	0.00097	0.00158	-0.00123	0.00138
1m	0.94656	0.94697	0.94526	0.94443	0.94822	0.94471	-0.00041	0.00130	0.00213	-0.00165	0.00184
1n	0.79292	0.79327	0.79193	0.79113	0.79432	0.79137	-0.00034	0.00109	0.00178	-0.00139	0.00155
1o	0.68766	0.68796	0.68671	0.68611	0.68886	0.68631	-0.00029	0.00094	0.00154	-0.00120	0.00134
1p	0.78239	0.78274	0.78131	0.78063	0.78377	0.78086	-0.00034	0.00108	0.00175	-0.00137	0.00153
2a	1.03395	1.03553	1.03260	1.03136	1.03655	1.03199	-0.00157	0.00135	0.00259	-0.00259	0.00196
2b	1.08323	1.08451	1.08181	1.08069	1.08570	1.08121	-0.00127	0.00141	0.00254	-0.00246	0.00202
2c	0.77662	0.77755	0.77557	0.77482	0.77839	0.77511	-0.00092	0.00105	0.00179	-0.00176	0.00150
2d	1.15799	1.15950	1.15649	1.15530	1.16077	1.15582	-0.00152	0.00148	0.00268	-0.00279	0.00215
2e	0.70150	0.70135	0.70027	0.69889	0.70215	0.69992	0.000151	0.00122	0.00261	-0.00065	0.00157
2f	0.93548	0.93593	0.93420	0.93325	0.93715	0.93367	-0.00045	0.00127	0.00212	-0.00167	0.00180
3a	0.87832	0.87905	0.87746	0.87669	0.88020	0.87695	-0.00073	0.00086	0.00162	-0.00188	0.00137
3b	0.66820	0.66849	0.66727	0.66669	0.66937	0.66689	-0.00029	0.00092	0.00150	-0.00116	0.00131
4	0.97006	0.92273	1.08236	1.24134	0.81834	1.12968	0.047329	-0.1123	-0.2712	0.151718	-0.1596
5	1.09434	1.09482	1.09283	1.09188	1.09626	1.09220	-0.00047	0.00151	0.00246	-0.00191	0.00214
6	0.74034	0.74066	0.73933	0.73867	0.74164	0.73891	-0.00032	0.00101	0.00167	-0.00130	0.00143
7	0.83394	0.83431	0.83279	0.83207	0.83540	0.83231	-0.00036	0.00115	0.00187	-0.00145	0.00163
8	1.13968	1.14017	1.13810	1.13712	1.14167	1.13744	-0.00049	0.00157	0.00256	-0.00199	0.00223
9	0.76930	0.76963	0.76823	0.76756	0.77064	0.76778	-0.00033	0.00106	0.00173	-0.00133	0.00151
10	0.80603	0.80638	0.80492	0.80422	0.80744	0.80445	-0.00035	0.00111	0.00181	-0.00141	0.00158
11	1.46299	1.46433	1.46105	1.45953	1.46603	1.46081	-0.00133	0.00194	0.00346	-0.00302	0.00278
12	1.22567	1.22614	1.22415	1.22221	1.22758	1.22352	-0.00046	0.00151	0.00345	-0.00191	0.00214
13	1.22132	1.22172	1.21995	1.21716	1.22307	1.21938	-0.00040	0.00136	0.00415	-0.00174	0.00193
14	1.18651	1.18703	1.18488	1.18385	1.18559	1.18419	-0.00051	0.00163	0.00266	-0.00207	0.00232
15	1.22458	1.22510	1.22291	1.22182	1.22673	1.22222	-0.00052	0.00167	0.00276	-0.00214	0.00236
16	0.99276	0.99319	0.99139	0.99053	0.99449	0.99082	-0.00043	0.00137	0.00222	-0.00173	0.00194
17	1.15323	1.15371	1.15169	1.15046	1.15520	1.15105	-0.00048	0.00154	0.00276	-0.00197	0.00218
18	1.04247	1.05131	1.04120	1.03943	1.05033	1.04066	-0.00883	0.00127	0.00304	-0.00785	0.00181
19	1.15963	1.15523	1.16978	1.10373	1.14580	1.17409	0.004406	-0.0101	0.05590	0.013835	-0.0144
20	1.07976	1.08022	1.07831	1.07712	1.08160	1.07769	-0.00046	0.00145	0.00263	-0.00183	0.00206
21	1.14398	1.14446	1.14243	1.14118	1.14593	1.14178	-0.00047	0.00155	0.00280	-0.00194	0.00220
22	0.98561	0.98561	0.98516	0.97906	0.98604	0.98499	-0.00000	0.00044	0.00655	-0.00042	0.00061
23	0.96716	0.96758	0.96583	0.96498	0.96885	0.96526	-0.00042	0.00133	0.00218	-0.00168	0.00190
24	1.21381	1.21435	1.21214	1.21105	1.21593	1.21145	-0.00054	0.00167	0.00275	-0.00212	0.00236
25	0.99034	0.99077	0.98897	0.98811	0.99207	0.98839	-0.00043	0.00136	0.00222	-0.00173	0.00194
26	1.14903	1.14953	1.14744	1.14642	1.15103	1.14677	-0.00050	0.00158	0.00260	-0.00200	0.00225

(CONTINUES) FOR AN EXPLANATION OF THE SIMULATIONS A, B, C, D, AND E; PLEASE REFER TO TABLE 12

APPENDIX 1.C. CALCULATION OF POWER OF DISPERSION FOR MEXICAN ECONOMY AND SIMULATION OF TECHNOLOGICAL CHANGE (CONTINUED)

							DIFFERENCE FROM BASELINE				
SECTOR	baseline	A	B	C	D	E	A	B	C	D	E
27	1.22075	1.22127	1.21905	1.21798	1.22288	1.21836	-0.00051	0.00169	0.00277	-0.00212	0.00239
28	1.18728	1.18777	1.18586	1.18377	1.18911	1.18528	-0.00049	0.00141	0.00350	-0.00183	0.00200
29	1.16948	1.17010	1.16797	1.16696	1.17163	1.16730	-0.00061	0.00151	0.00251	-0.00215	0.00218
30	1.14155	1.14206	1.13998	1.13898	1.14356	1.13933	-0.00050	0.00157	0.00256	-0.00200	0.00222
31	1.13466	1.13517	1.13312	1.13208	1.13666	1.13249	-0.00050	0.00154	0.00258	-0.00199	0.00217
32	1.05911	1.05957	1.05766	1.05670	1.06095	1.05702	-0.00046	0.00144	0.00240	-0.00184	0.00208
33	1.22755	1.22808	1.22586	1.22479	1.22970	1.22514	-0.00052	0.00169	0.00276	-0.00214	0.00241
34	1.18776	1.18827	1.18613	1.18505	1.18983	1.18543	-0.00051	0.00163	0.00270	-0.00206	0.00233
35	0.96307	0.96349	0.96175	0.96088	0.96475	0.96120	-0.00041	0.00132	0.00219	-0.00167	0.00186
36	1.24999	1.25043	1.24816	1.24708	1.25208	1.24744	-0.00054	0.00172	0.00281	-0.00219	0.00244
37	1.16558	1.16608	1.16396	1.16295	1.16761	1.16330	-0.00050	0.00161	0.00262	-0.00203	0.00227
38	0.95061	0.95100	0.94934	0.94826	0.95221	0.94878	-0.00039	0.00126	0.00235	-0.00160	0.00182
39	1.12308	1.12359	1.12155	1.12052	1.12504	1.12088	-0.00050	0.00152	0.00255	-0.00196	0.00219
40	1.09719	1.09767	1.09571	1.09464	1.09908	1.09506	-0.00048	0.00148	0.00254	-0.00188	0.00213
41	1.04668	1.04713	1.04523	1.04432	1.04851	1.04462	-0.00045	0.00144	0.00236	-0.00183	0.00205
42	0.95097	0.95139	0.94966	0.94883	0.95264	0.94911	-0.00041	0.00131	0.00214	-0.00166	0.00186
43	1.04787	1.04833	1.04642	1.04551	1.04970	1.04582	-0.00045	0.00144	0.00236	-0.00183	0.00204
44	1.10673	1.10721	1.10520	1.10424	1.10867	1.10455	-0.00048	0.00152	0.00249	-0.00193	0.00217
45	0.98997	0.99040	0.98860	0.98774	0.99170	0.98904	-0.00043	0.00136	0.00222	-0.00173	0.00193
46	1.28123	1.28178	1.27946	1.27835	1.28347	1.27871	-0.00055	0.00176	0.00287	-0.00224	0.00251
47	1.18426	1.18478	1.18263	1.18160	1.18633	1.18193	-0.00051	0.00163	0.00266	-0.00206	0.00232
48	1.18909	1.18961	1.18746	1.18641	1.19117	1.18676	-0.00052	0.00162	0.00267	-0.00208	0.00232
49	1.16476	1.16526	1.16315	1.16214	1.16680	1.16248	-0.00050	0.00160	0.00261	-0.00203	0.00227
50	0.94089	0.94130	0.93959	0.93878	0.94254	0.93905	-0.00040	0.00129	0.00211	-0.00164	0.00184
51	0.98035	0.98078	0.97900	0.97815	0.98206	0.97843	-0.00043	0.00134	0.00219	-0.00171	0.00191
52	1.07191	1.07238	1.07043	1.06950	1.07379	1.06981	-0.00046	0.00148	0.00241	-0.00187	0.00210
53	1.14598	1.14647	1.14439	1.14339	1.14798	1.14373	-0.00049	0.00158	0.00259	-0.00199	0.00224
54	1.08203	1.08250	1.08054	1.07960	1.08392	1.07991	-0.00047	0.00149	0.00243	-0.00189	0.00212
55	1.01321	1.01365	1.01181	1.01093	1.01498	1.01122	-0.00044	0.00139	0.00227	-0.00177	0.00199
56	1.13563	1.13613	1.13406	1.13307	1.13762	1.13340	-0.00049	0.00156	0.00256	-0.00198	0.00222
57	1.16755	1.16806	1.16594	1.16491	1.16959	1.16526	-0.00050	0.00161	0.00263	-0.00204	0.00228
58	1.05463	1.05509	1.05318	1.05225	1.05648	1.05257	-0.00046	0.00145	0.00237	-0.00185	0.00205
59	1.01044	1.01089	1.00906	1.00815	1.01220	1.00848	-0.00044	0.00138	0.00229	-0.00176	0.00196
60	1.16380	1.16432	1.16220	1.16119	1.16585	1.16154	-0.00051	0.00160	0.00261	-0.00204	0.00226
61	0.99660	0.99704	0.99523	0.99435	0.99835	0.99465	-0.00043	0.00137	0.00224	-0.00174	0.00194
62	0.78708	0.78742	0.78599	0.78531	0.78846	0.78554	-0.00034	0.00108	0.00176	-0.00137	0.00154
63	0.83170	0.83206	0.83055	0.82983	0.83315	0.83007	-0.00036	0.00114	0.00187	-0.00145	0.00163
64	0.89317	0.89356	0.89194	0.89116	0.89473	0.89142	-0.00038	0.00123	0.00201	-0.00156	0.00175
65	0.75724	0.75757	0.75620	0.75554	0.75857	0.75576	-0.00032	0.00104	0.00170	-0.00132	0.00148
66	0.84492	0.84528	0.84375	0.84302	0.84639	0.84326	-0.00036	0.00116	0.00189	-0.00147	0.00165
67	0.72590	0.72622	0.72490	0.72427	0.72717	0.72448	-0.00031	0.00100	0.00163	-0.00127	0.00142
68	0.82939	0.82975	0.82825	0.82753	0.83084	0.82777	-0.00036	0.00114	0.00186	-0.00145	0.00162
69	0.77370	0.77404	0.77264	0.77194	0.77505	0.77221	-0.00033	0.00106	0.00175	-0.00134	0.00149
70	0.89250	0.89283	0.89138	0.88979	0.89389	0.89090	-0.00032	0.00112	0.00271	-0.00138	0.00160
71	0.92676	0.92717	0.92548	0.92468	0.92838	0.92494	-0.00041	0.00128	0.00208	-0.00162	0.00181
72	0.90284	0.90324	0.90160	0.90081	0.90442	0.90107	-0.00039	0.00124	0.00203	-0.00157	0.00177

Source: Calculated by author from INEGI, 1988.

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